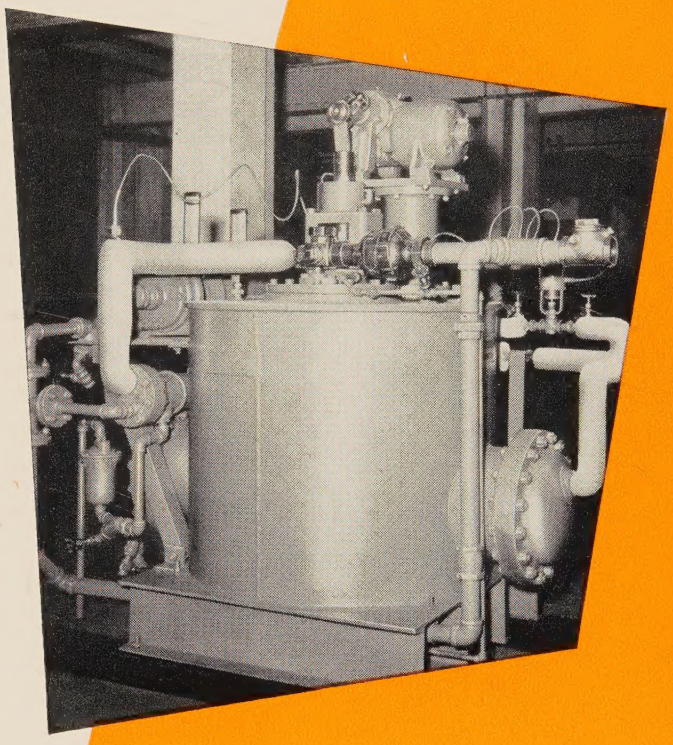
Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

MARCH 1951

ANOTHER PRACTICAL PAPER
PROBLEM SOLVED BY
HERCULES RESEARCH

Now—a New Simplified Hercules Automatic Emulsifier



HERCULES' TECHNICAL RESEARCH in the rosin size field has once again resulted in an improved, amazingly simple, automatic emulsifying unit that merits the attention of paper manufacturers everywhere. This new automatic emulsifier is lower in price than the first Hercules automatic emulsifying unit introduced to the paper trade in 1948.

The original Hercules automatic emulsifying unit was the first in its field, and offered a completely new technique in handling and emulsifying paste rosin size.

Twenty paper mills have already installed this revolutionary rosin size emulsifying process, and additional units are scheduled for early installation. Write for details.

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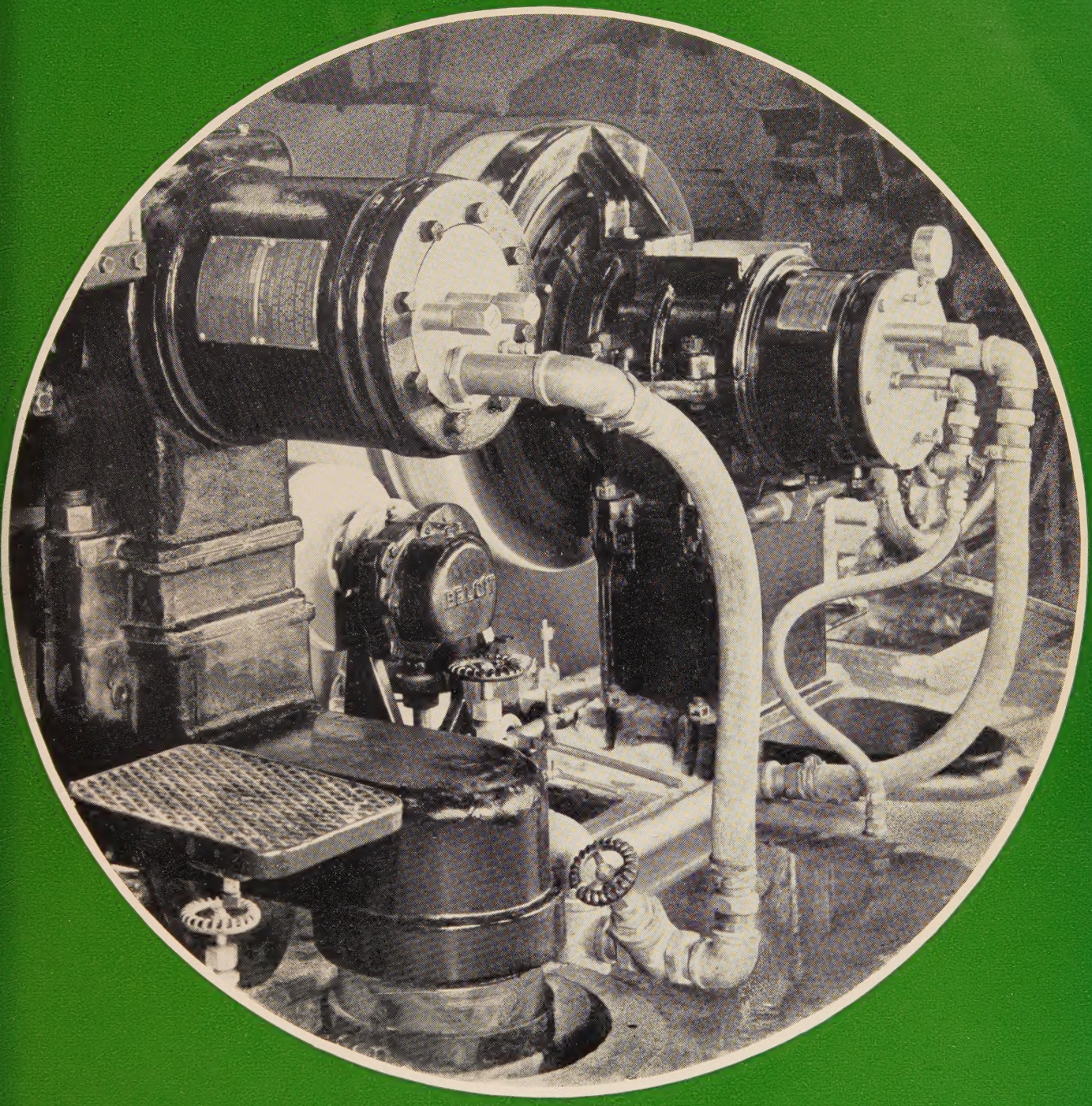

Increased Production from Beloit Suction Rolls

Above: a rubber-covered Suction Press (as part of a patented Beloit Dual Press) and a Beloit Suction Couch. Efficient removal of water makes increased machine speed possible. Some Fourdrinier machines profitably use as many as five Beloit Suction Rolls in couch, pick-up, and press positions. Mill managers report increased production with sharply reduced cost of felt and wire per ton of paper.—*Beloit Iron Works.*

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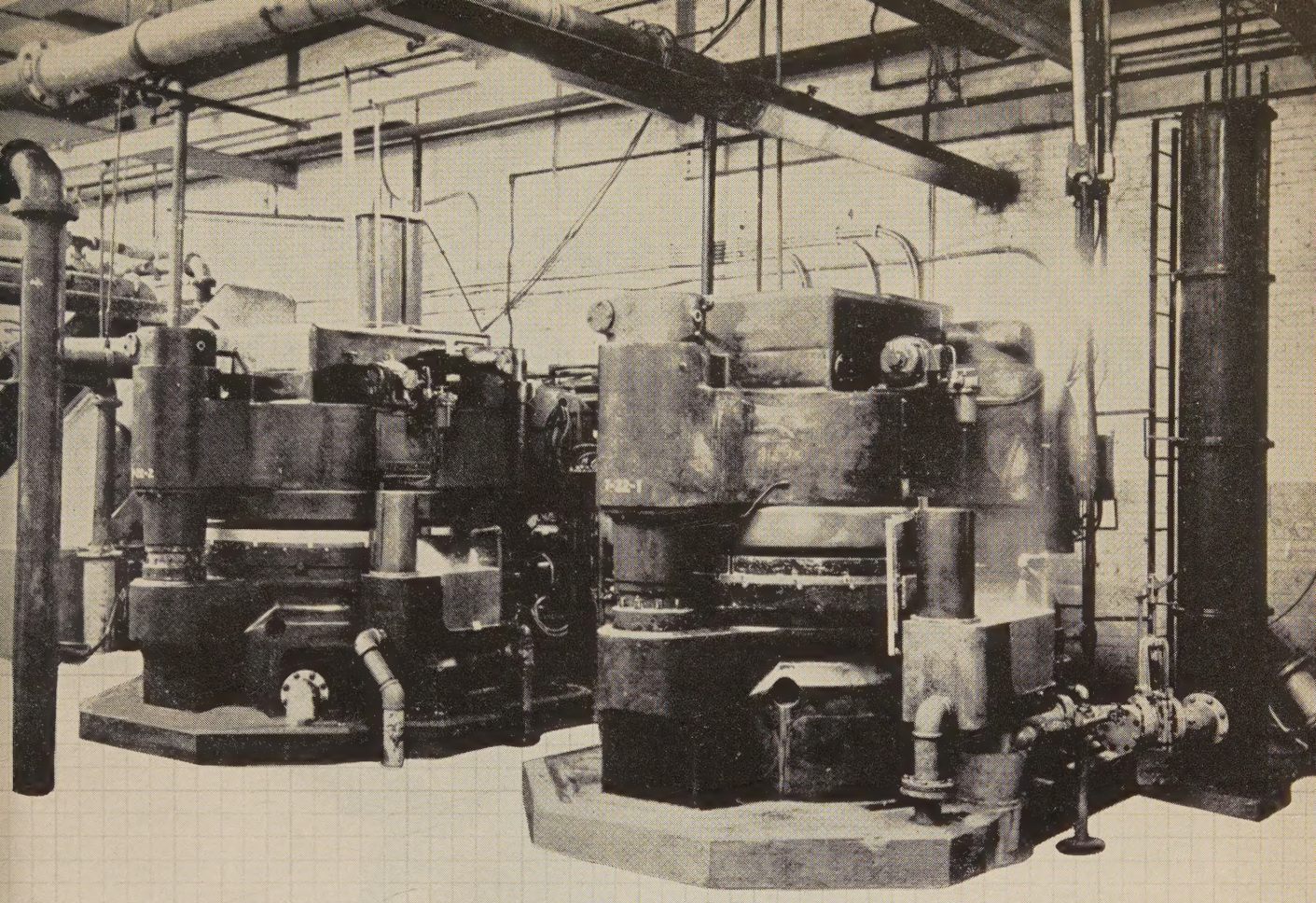
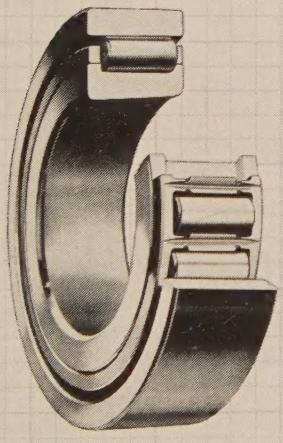


giving fiber a "permanent"



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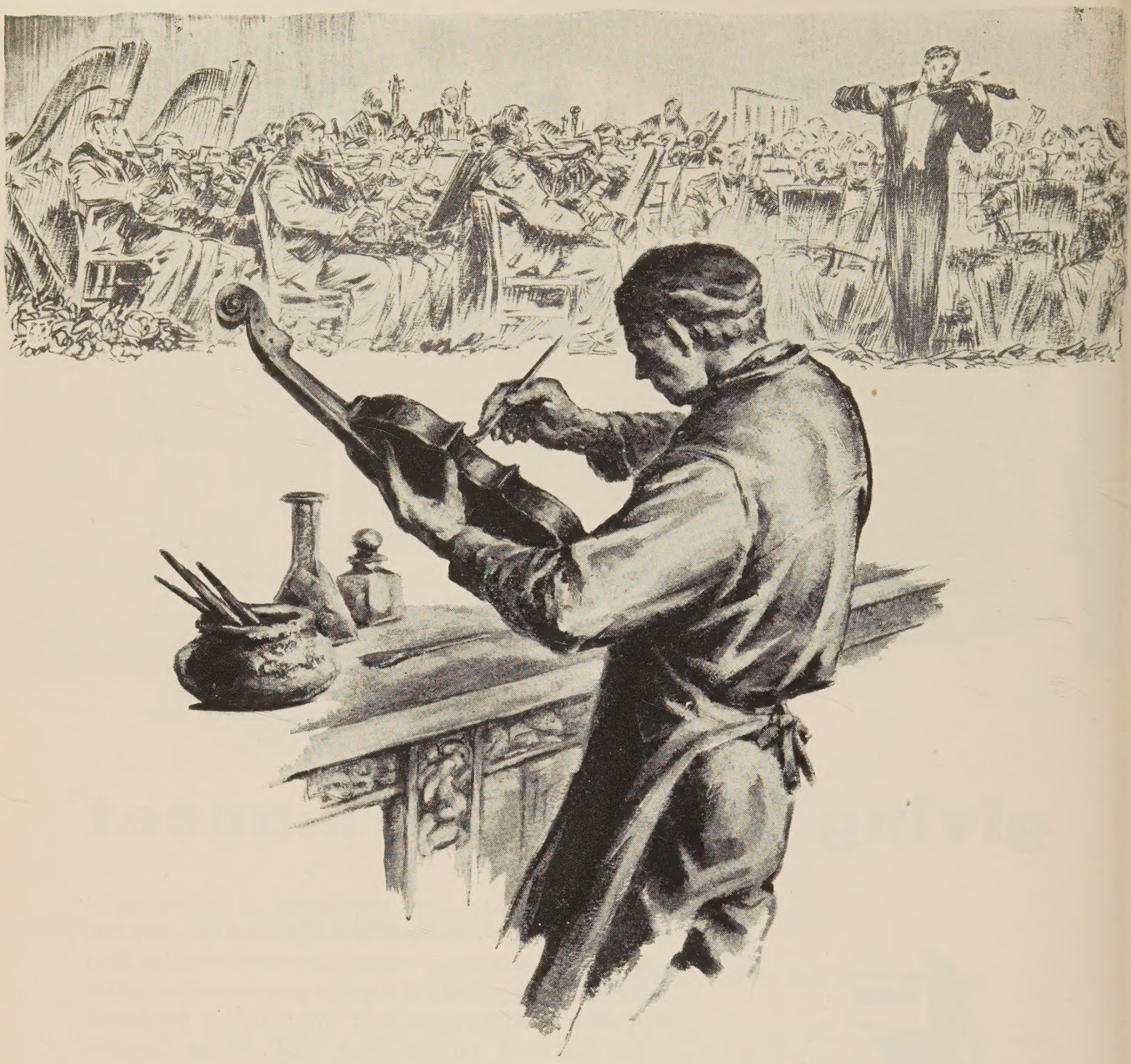

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MARCH 1951

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VOL. 34 · NO. 3

Published monthly by the Technical Association of the Pulp and Paper Industry

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Published monthly by the Technical Association of the Pulp and Paper Industry at 20th and Northampton Streets, Easton, Pa. Editorial and advertising offices, 122 East 42nd Street, New York 17, N. Y. Articles for publication and communications regarding the editorial content of *Tappi* should be addressed to the Editor at the editorial office. Statements and opinions expressed in articles and editorials appearing in *Tappi* are those of the contributors, and the Technical Association of the Pulp and Paper Industry assumes no responsibility for them. Subscription: U. S. and possessions, $7.50; Canada, $8.25; Pan American Union, $9.00; Other Foreign, $10.00. Single copies to members of TAPPI, $0.75; Nomnembers, $1.00. Entered as second class matter January 27, 1949, at the Post Office at Easton, Pa., under the act of August 24, 1912. Copyright, 1951, by the Technical Association of the Pulp and Paper Industry. An index of the technical articles appearing in the magazine appears in the Industrial Arts Index and the Engineering Index.

Announcing

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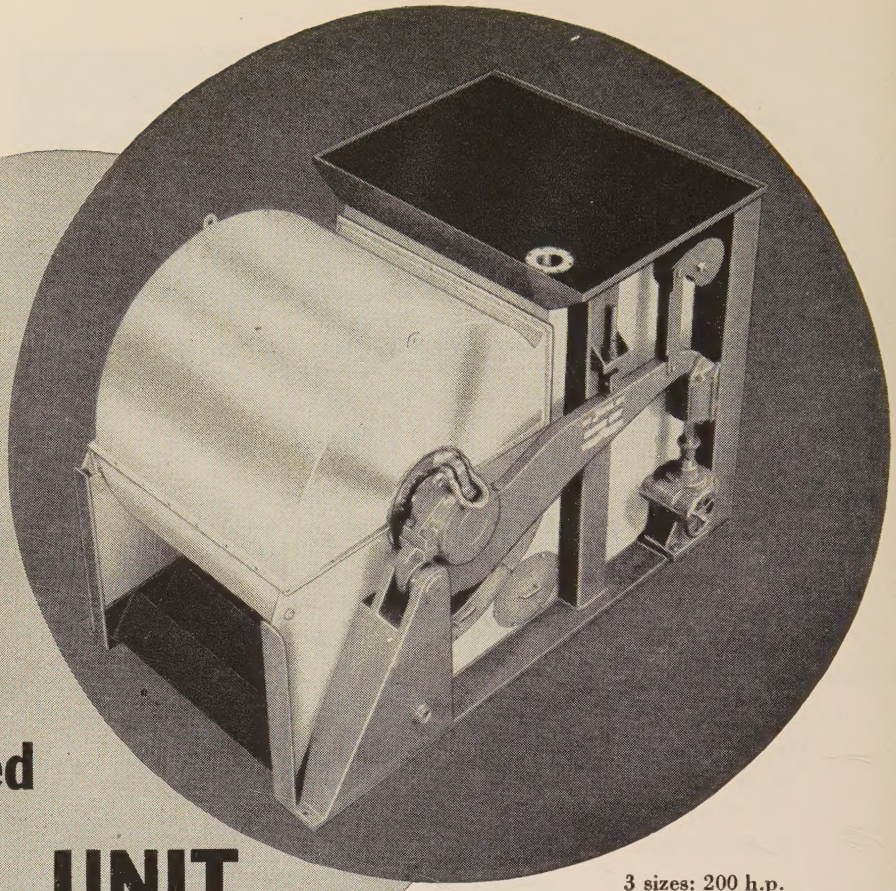
(patent applied for)



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- ★ **Requires less floor space — motor support is an integral part of the unit**
- ★ **Lower maintenance — completely non-corrosive where exposed to stock**

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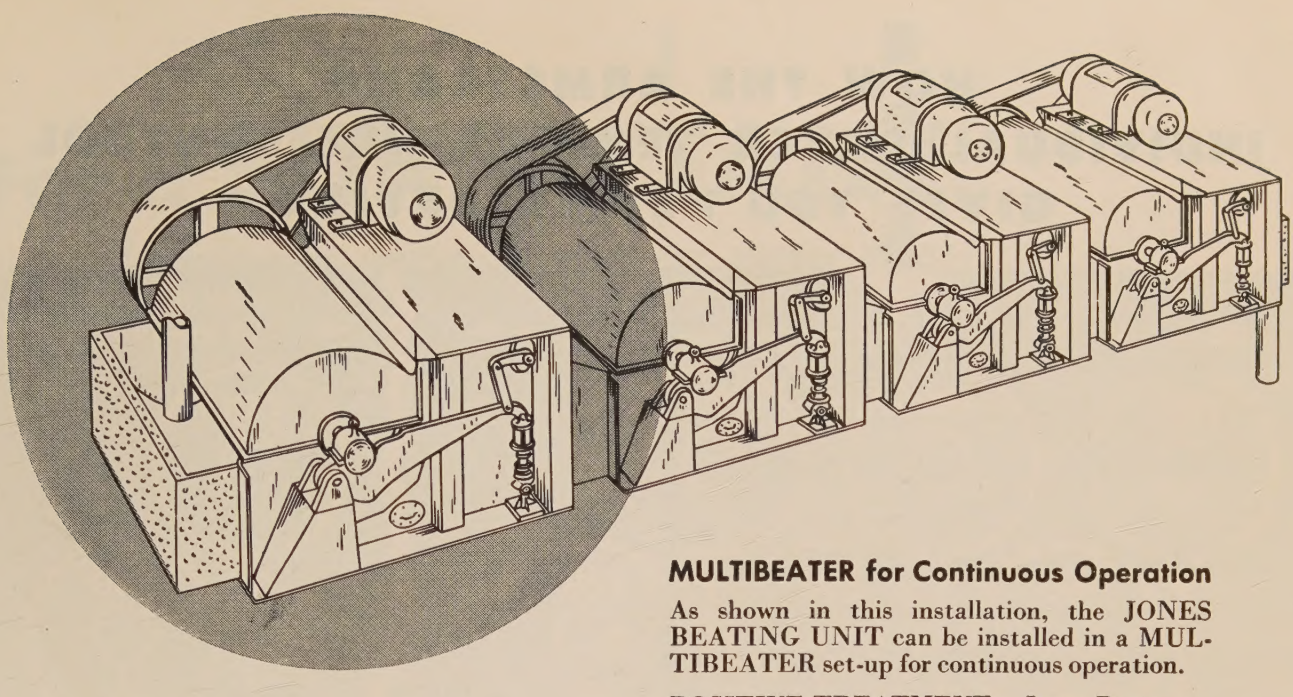

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As shown in this installation, the JONES BEATING UNIT can be installed in a MULTIBEATER set-up for continuous operation.

POSITIVE TREATMENT: Jones-Bertrams-type roll and bed plates with positive control of roll pressures and re-circulation make it impossible for untreated stock to pass through the unit.

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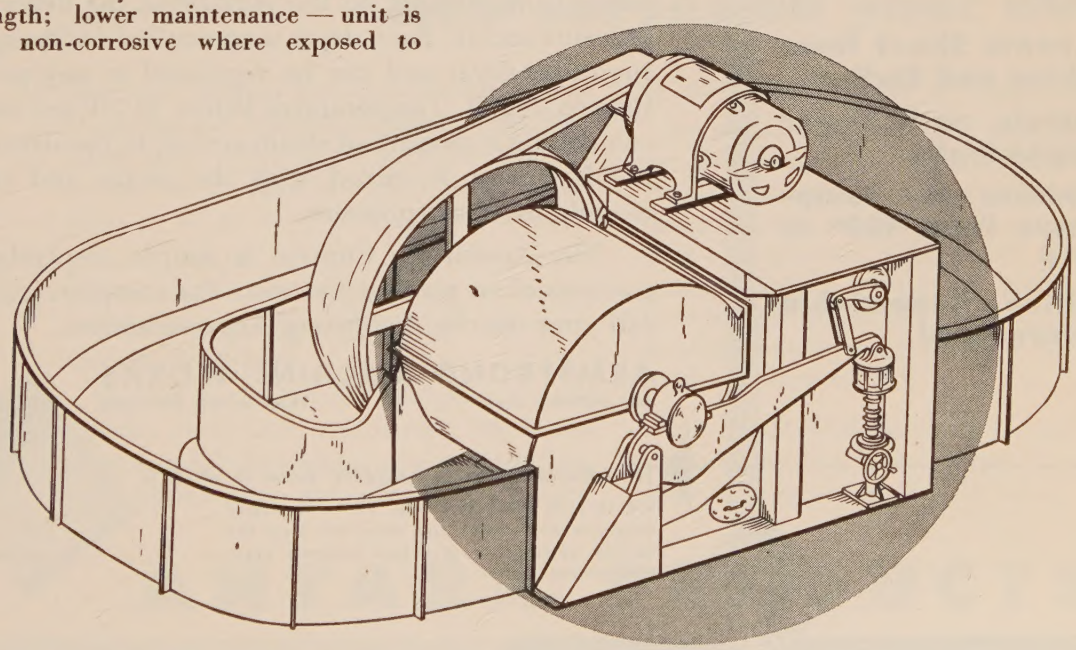

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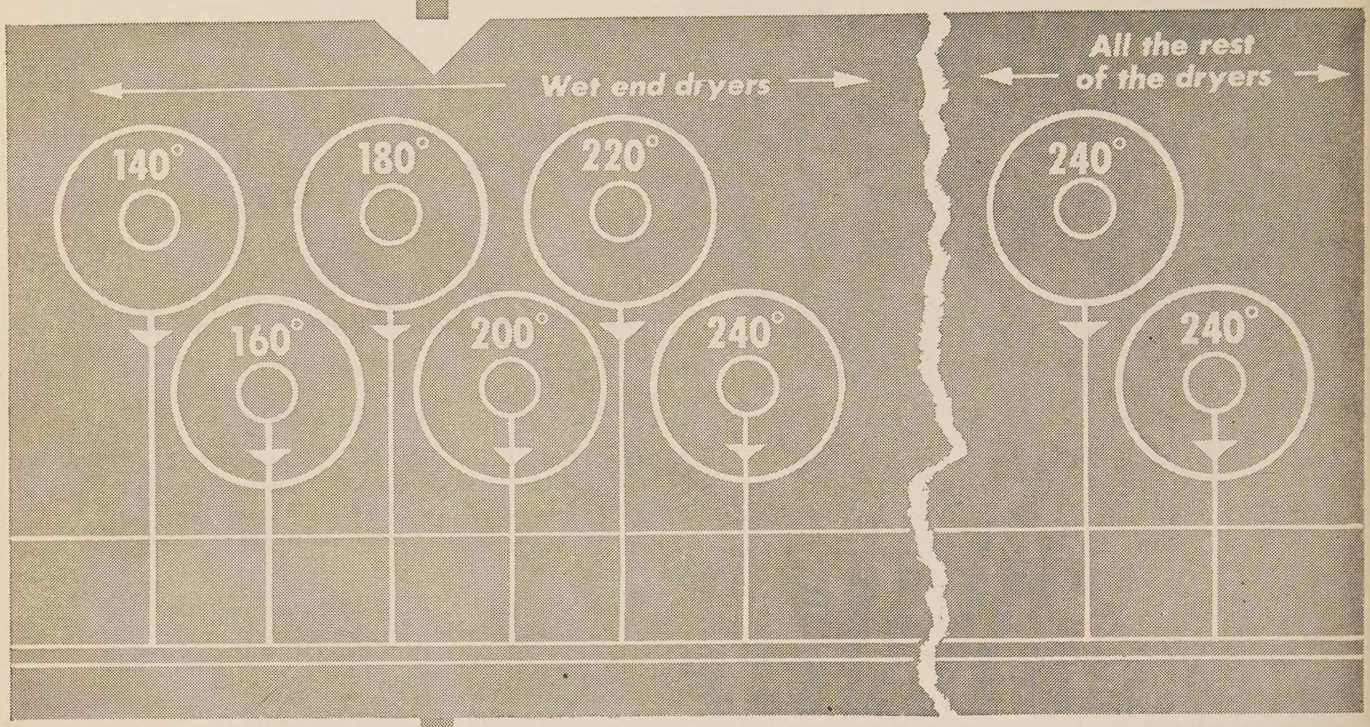

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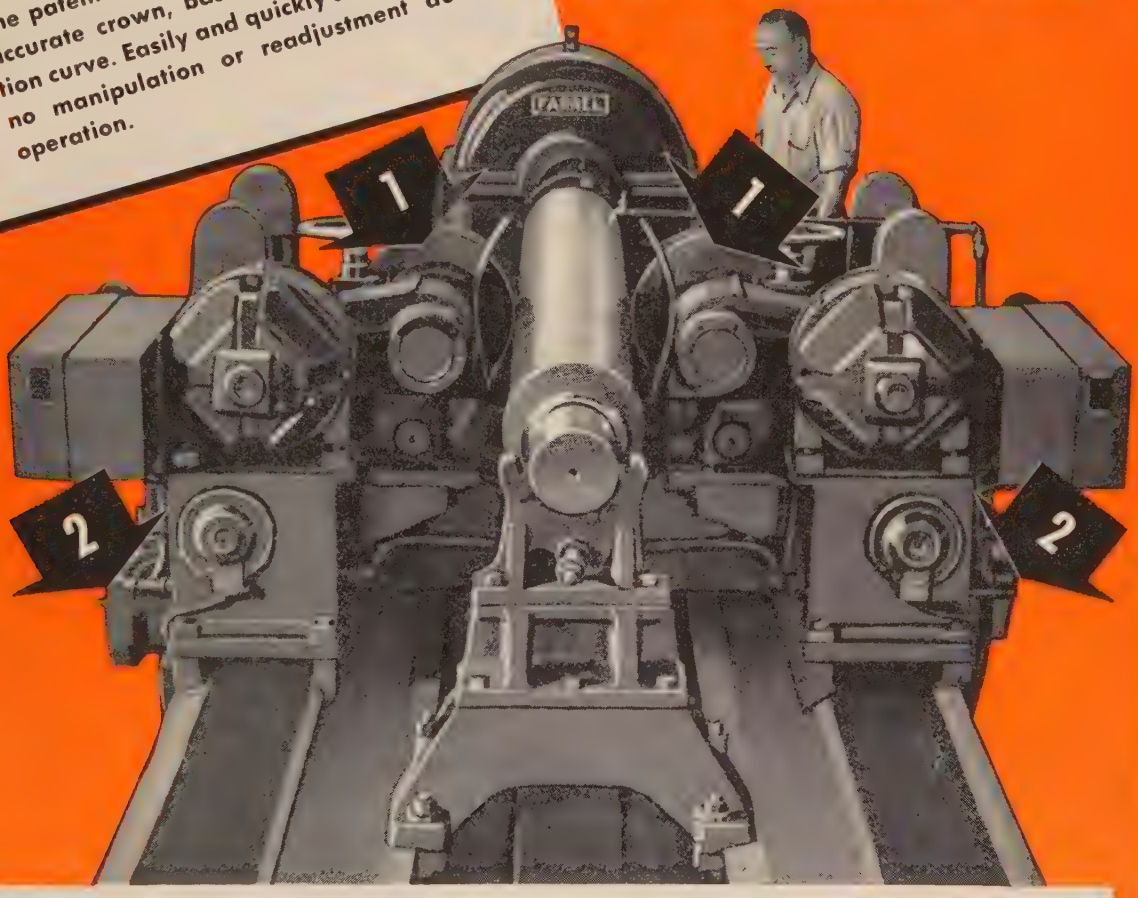

When you use Farrel two-wheel, swing-rest roll grinders you can specify definite standards of accuracy and uniformity, and then insist that they be adhered to faithfully and reproduced on any number of rolls. This is possible because, in designing the machine, much of the skill formerly required by the operator, was transferred to the mechanism. The necessity for "cut-and-try" methods has been eliminated.

Well known throughout the paper industry for many years, the Farrel swing-rest machine has recently been redesigned to provide faster grinding and finer finishes, with even closer control of roll accuracy and crown shape.

The swing-rest principle and the patented crowning device, as well as the many other features of the Farrel two-wheel roll grinder, are described in detail in Bulletin No. 118. Send for your copy today. No cost or obligation.

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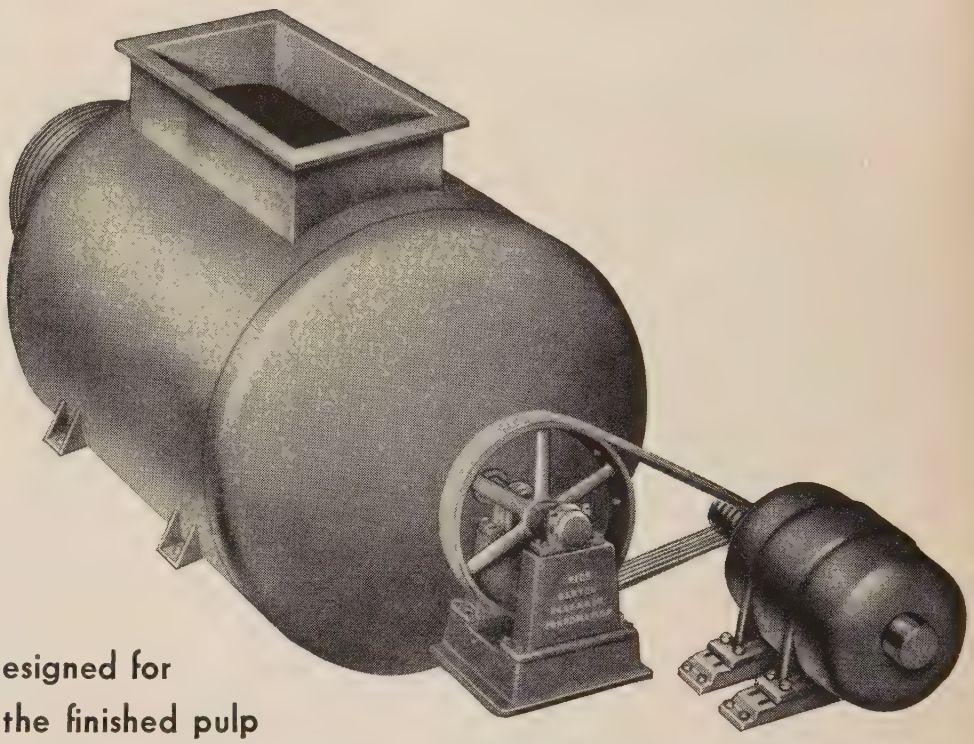

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The DynoPeller

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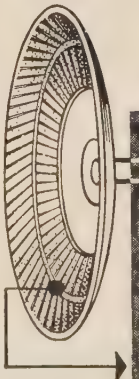

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The PRESIDENT'S PAGE

K. P. Geohegan

To all of the members of TAPPI, I wish to express my deep appreciation for the opportunity to serve you as President. I realize that it is an honor but, more than that, an obligation; and I assure you that I will do everything in my power to fulfill that obligation and to further your interests

During the past two years, Mr. Bachmann's leadership has been inspiring. I only hope that I can approach his success in understanding the needs of the Association and his initiative in outlining the proper approach to so many of our problems.

As you know, TAPPI has grown tremendously during the past few years. That growth has made more complex the problems that face the Executive Committee, and has increased the difficulty of planning a program that will best benefit you and the industry as a whole. At the same time, it has made it harder to keep a close personal contact between the individual members and the national organization.

During the coming year, I would like to use this page to tell you informally about some of the problems with which the Executive Committee is struggling and about some of the committee's plans.

For example, there is the problem of welding the work of the various divisions and committees into a coherent research program in such a way that their results will not overlap and so that the entire program will be headed toward a definite goal. All of us are indebted to the unselfish work that is being done by the divisional and committee chairmen. If we have not been taking the fullest possible advantage of the results of their efforts, it is our fault and not theirs. We have an obligation to support them and to give them assistance wherever we can.

In the next issue of *Tappi* I plan to have a message for committee chairmen. At first sight it would appear that this would not be of interest to committee members nor to those members of TAPPI who are not on the various committees. However, I do not feel that this is the case. If all of you understand the general attitude and the problems of the committee chairmen you will be in a better position to offer constructive suggestions; and there is not a chairman who does not need all of the help that he can obtain.

Then, there is the question of local sections. As I have visited one section after another I have been more than impressed by their enthusiasm, by the hard work being done by their officers, by the keen interest shown by their members, and by the quality of papers that are presented at their meetings. New sections are being formed; but we must be sure that we furnish them as well as the older sections with the assistance that can come only through a close relationship with the parent organization.

As you read these pages during the coming year, if you have any suggestions to offer, please write to a committee chairman, to a member of the Executive Committee, to me, or to whomever you think would benefit most by your idea. Obviously, all suggestions cannot be followed; but I can assure you that every one will be given careful consideration and that your interest and your help will be more than appreciated.

KENNETH P. GEOHEGAN
President of TAPPI

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PULP, PAPER, AND BOARD: 1950

Table I. United States Production of Wood Pulp and Consumption of Wood Pulp, Pulpwood and Other Fibrous Materials in the Manufacture of Paper and Board, by Kinds, 1950 and 1949 (Tons of 2000 Pounds)

Item	Production		Consumption	
	1950 Preliminary	1949	1950 Preliminary	1949
All Fibrous Materials (Excluding Pulpwood)	14,827,152	12,171,786	25,830,965	21,421,082
Wood Pulp, Total	14,827,152	12,171,786	16,487,110	13,606,387
Sulphite, total	2,855,825	2,536,284	3,331,668	3,011,662
Bleached	2,111,332	1,829,021	2,072,356	1,850,246
Unbleached	744,493	707,263	1,259,312	1,161,416
Sulphate, total	7,508,376	5,977,281	8,380,864	6,677,764
Bleached	1,422,483	1,118,282	1,844,322	1,484,489
Semibleached	374,958	263,637	404,458	277,449
Unbleached	5,710,935	4,595,362	6,132,084	4,915,826
Soda	522,990	492,194	564,355	525,877
Groundwood	2,220,795	1,960,496	2,483,980	2,184,409
All other	1,719,166	1,205,531	1,726,243	1,206,675
Fibrous Materials Other Than Wood Pulp, Total	...	...	9,343,855	7,814,695
Waste paper	...	...	7,903,612	6,599,606
Straw	...	...	405,756	385,890
Rags	...	...	442,330	381,915
Flax	...	...	[a]	53,332
Miscellaneous fiber	...	...	[a]	393,952
Pulpwood, Total (Cords of 128 cu. ft.—roughwood basis)	...	...	23,656,109	19,945,440
Softwood	...	...	20,444,674	17,330,495
Hardwood	...	...	3,211,435	2,614,945

[a] Withheld to avoid disclosing data for individual companies.
Source: Data represent a summation of the monthly "Facts for Industry" reports (Series M14A) for the industry, revised to include late and corrected reports received subsequent to the publication of the monthly releases.

Paper and board production totaled 24,300,178 tons and wood pulp production amounted to 14,827,152 tons in 1950, according to a preliminary report issued recently by the Bureau of the Census, Department of Commerce. These figures are all-time records. They represent increases from the 1949 output of 20% in paper and board and 22% in wood pulp production.

Paper production, exclusive of building grades, totaled 10,679,329 tons, almost one and one-half million tons greater than the 1949 figure. Production of all major grades except groundwood paper increased over 10% in 1950. Production of groundwood paper in 1950 was only 3% more than that reported for 1949.

Paperboard output in 1950 amounted to 10,803,968 tons 20% more than that reported for 1949. Construction paper and board production amounted to 2,672,990 tons, almost 700,000 tons more than 1949. Production of insulating board and hardboard amounted to 1,258,620 tons, approximately 50% more than the 1949 figure.

This report was prepared by Bureau of the Census, Industry Division, Chemicals and Wood Products Section.

Wood pulp production increased about 22% to 14,827,152 tons. The percentages of increase of the individual grades of wood pulp were as follows: bleached sulphite, 15; unbleached sulphite, 5; bleached sulphate, 27; semibleached sulphate, 42; unbleached sulphate, 24; soda, 6; groundwood, 13; and all other (semichemical, defibrated, screenings, etc.), 43.

The consumption of wood pulp and fibrous materials other than wood pulp in the manufacture of paper and board amounted to 16,487,110 tons and 9,343,855 tons, respectively, an increase of about 20% in each case. The pulp mills consumed 23,656,109 cords of pulpwood measured on a roughwood basis, an increase of 19% over 1949. The consumption of hardwood species of pulpwood increased by 23%.

The preliminary 1950 data are the result of a summation of the monthly reports on Form M14A, "Domestic Pulp and Paper Monthly Report." The statistics represent a complete coverage of the operations of all known wood pulp, paper and board mills. Final and more detailed data will be published in a summary report at a later date.

Table II. Paper and Board Production in the United States: 1948, 1949, and 1950 (Tons of 2000 Pounds)

Item	1950 Preliminary	1949	1948	Item	1950 Preliminary	1949	1948
All Types, Total	24,300,178	20,327,222	21,928,348	Paperboard (*Continued*)			
Paper, Total	10,679,329	9,209,393	9,805,347	Liners	3,689,672	3,129,262	3,436,305
Newsprint	1,017,322	917,778	875,760	Corrugating material	1,636,430	1,306,868	1,372,691
Groundwood paper	694,146	674,542	771,850	Container chip and filler board	320,331	244,924	269,933
Printing and converting paper	1,014,516	911,878	798,407	Folding boxboard	2,368,010	2,084,415	2,199,608
Book paper	1,577,385	1,395,755	1,580,742	Set-up boxboard	641,345	617,249	596,190
Fine paper	1,222,637	1,014,954	1,140,859	Cardboard	77,322	83,204	86,791
Coarse paper (including shipping sack)	3,383,400	2,764,917	3,027,098	All other paperboard	2,070,858	1,527,042	1,408,529
Special industrial paper	315,905	250,621	315,539	Wet Machine Board	143,891	124,511	134,285
Sanitary paper	1,108,021	1,006,168	982,692	Construction Paper and Board, Total	2,672,990	2,000,354	2,618,669
Tissue paper	240,604	186,667	205,095	Building paper and insulation	1,414,370	1,161,625	1,348,321
Absorbent paper	105,393	86,113	107,305	Hardboard and insulating board	1,258,620	838,729	1,270,348
Paperboard, Total	10,803,968	8,992,964	9,370,047				

Source: Data for 1950 are compiled from reports on Form M14A, "Domestic Pulp and Paper Monthly Report." Data for 1949 and 1948 are from "Facts or Industry" Series M14D.1-09, "Paper and Board Production—1949."

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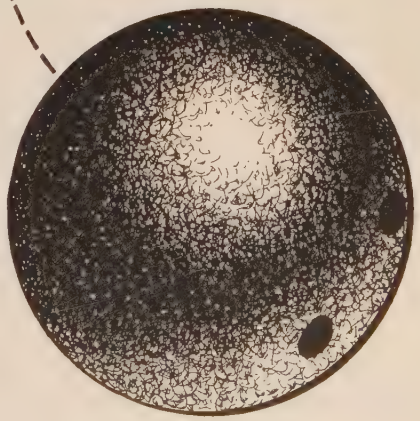

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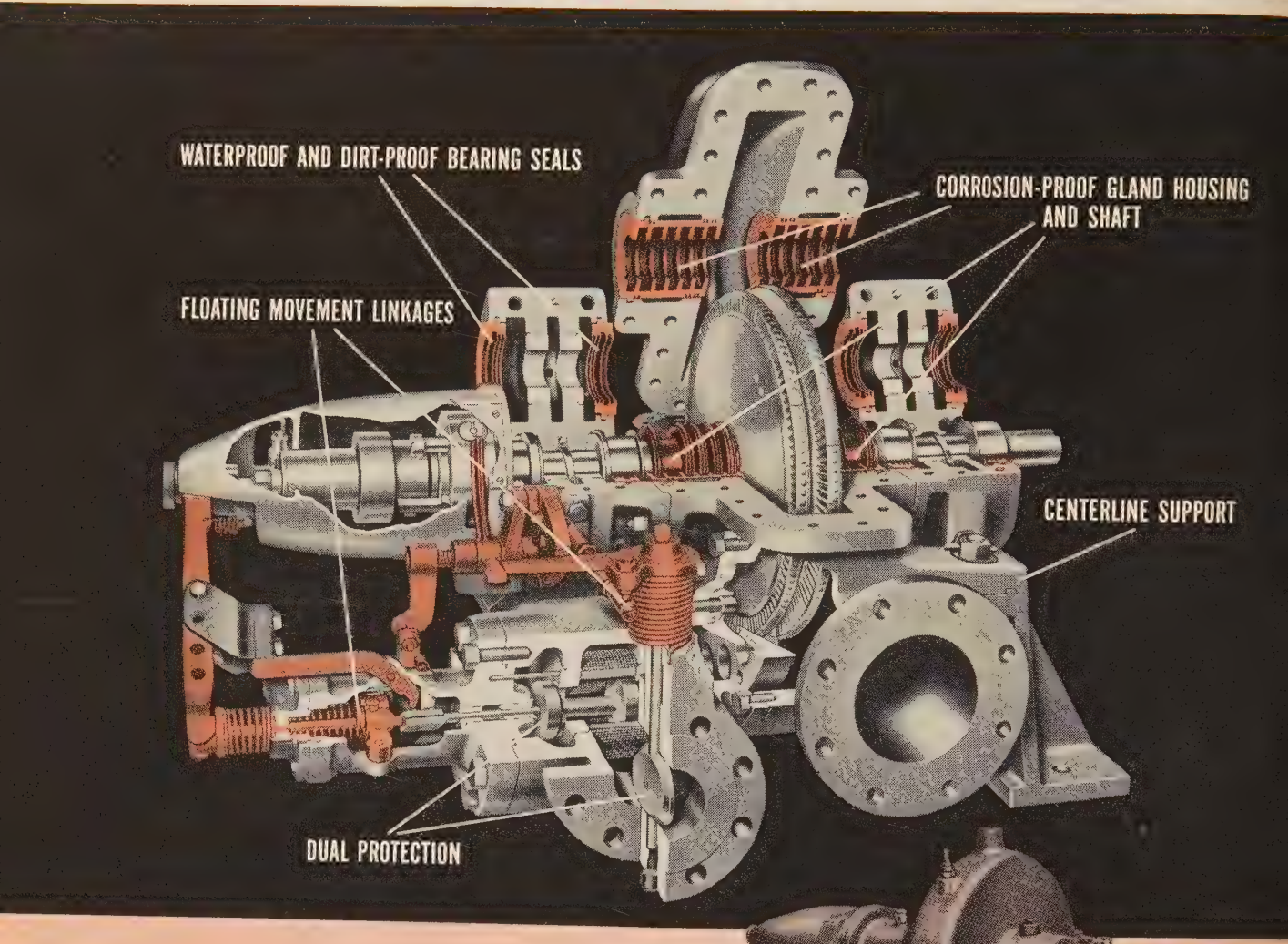

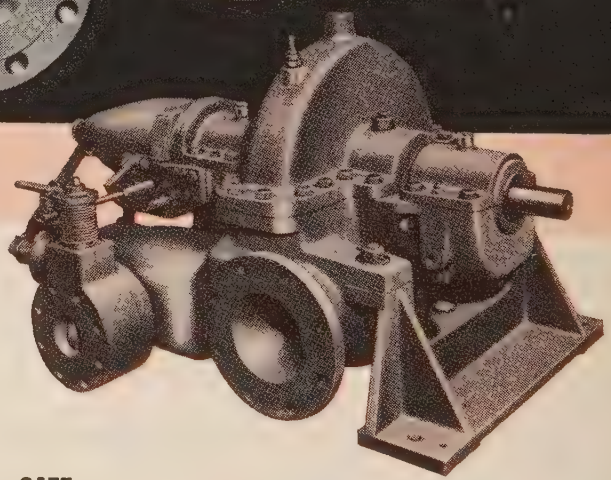

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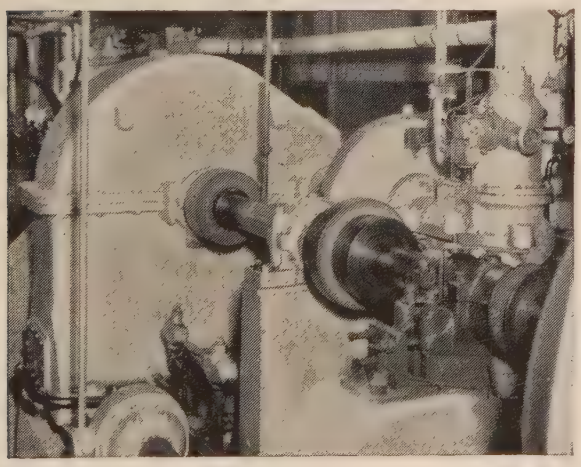

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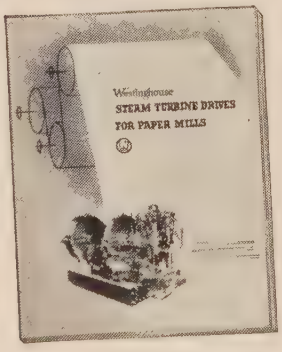

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J. D. ZELLERBACH

PLEASE have no illusions that I came from San Francisco to this TAPPI convention in the role of an oracle on world affairs, or to prescribe some miracle medicine for curing international sickness. Like yourselves, I am an American papermaker who believes that the political and economic system under which we operate in the United States, while not perfect, is the best there is and well worth fighting for.

More than four years ago, while in Europe as the American industry delegate to the International Labor Conference, I saw Russian Communism (I prefer to call it Red Fascism) try to force its way into control of this constructive and socially minded international body. I saw it conspiring to win control of the governments of most of the countries of Europe and succeeding in some of them. I saw our way of doing things in America threatened by a red tide which was moving toward us from the East. From that trip I came home to America convinced that the Russian leaders had no intention of joining the free world nations in any movement for ensuring peace and tranquility. It seemed to me that their membership in the United Nations was being used as a platform from which to broadcast their lying propaganda. I made up my mind that if we valued our freedoms, our businesses, and our necks, then American businessmen and industrialists would have to take time out from their busy affairs and help do something about saving those freedoms. There were not too many who recognized this in the beginning.

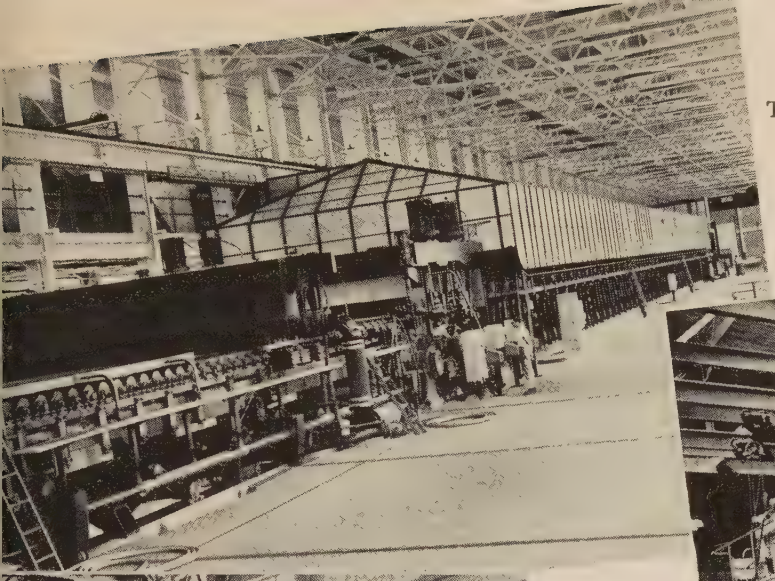
My opportunity came shortly after the inception of the now historic and successful Marshall Plan for assisting the free countries of Europe to rebuild from the ravages of war. In July, 1948, I went to Italy to administer the Marshall Plan there. I talked with everyone from government leaders to homeless peasants. I saw for myself what seemed most needed to revitalize Italy, and with an able group of American associates and Italian government leaders, we set about the task. The outlook for success was not too promising. Italy was flat on its back economically as a result of 20 years of Fascist autarchy, war, and destruction. The government which had just been elected had to contend with a parliament in which 30% of the members were Communists who were backed by the largest Communist party outside of Russia. The Kremlin had already issued orders to its followers to oppose the Marshall Plan and to sabotage its work in every possible way and Communist leaders in Italy followed orders.

I am convinced that had it not been for the hope for a brighter future which was held out by the Marshall Plan to the people of Europe, particularly Italy and France; and if it had not been for the confirmation of those hopes made possible by supplying American funds and American technical know-how to assist in rebuilding Western Europe, Communist tanks would now be posed along the English Channel. I have been asked to discuss with you some phases of this crisis and the effectiveness of the Marshall Plan in dealing with it.

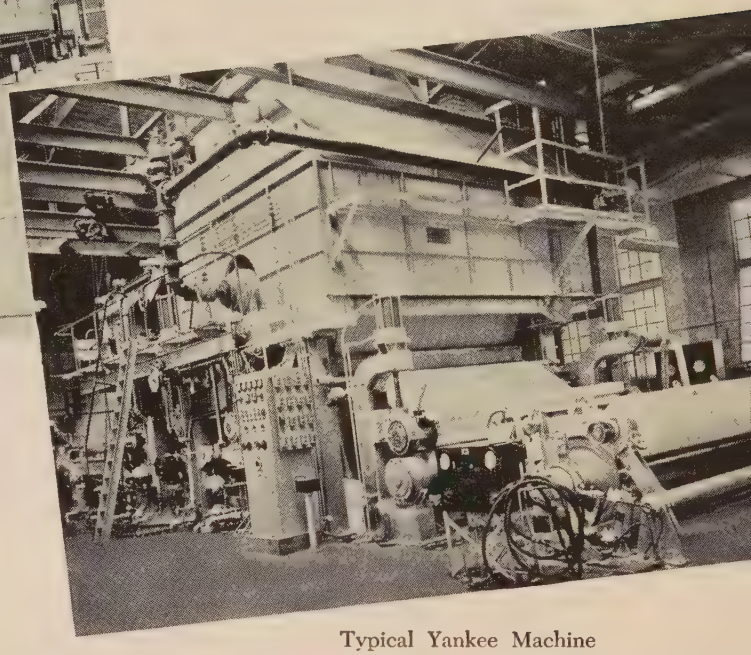
To do so, it seems necessary to roll back five years of history and admit mistakes which are quite transparent now. The mistakes of foreign policy made at Teheran, Yalta, and Potsdam can be blamed on our Government leaders but we cannot blame them for the rapid dissipation of our military strength following the war which left no effective force to counter the Red seizure of power in Eastern Europe and China. This, our greatest mistake, is chargeable to "We the people." In our sentimental desire to see the boys brought quickly home from Europe and Asia, we ourselves forced a government policy which led to almost total disarmament and demobilization. This at a time when Russia was building her war machine and stepping up her propaganda warfare against any nation not in full agreement with her. We watched her move into free countries by force or intrigue or both, while we continued to produce automobiles, refrigerators, and radios and hoped for the best. In those five or more years there were only two major successes of foreign policy to which we can point with pride. One was the Berlin airlift which flew successfully against Russia's cold war. The other was the Marshall Plan which can largely be credited with halting in its tracks the onward sweep of Russian Communism across Europe.

World history does not disclose a record where one great nation ever before assumed the responsibility for an aid program the equal of the Marshall Plan. Never before had any nation undertaken to assist other nations—friend and foe—to rebuild their industries, restore their agriculture, stabilize their currencies, revitalize transport systems, eliminate trade barriers, restore national strength, and integrity. And all this without requesting or demanding special concessions, political, military, or economic. The Marshall Plan struck a blow against low standards of living, against hunger, hopelessness, and despair in whose soils the seeds of Communism take root and flourish. The Marshall Plan demonstrated the honesty of American

J. D. ZELLERBACH is President, Crown Zellerbach Corp., and former Chief of E.C.A. Special Mission to Italy, San Francisco, Calif.



Typical Liner Board Machine



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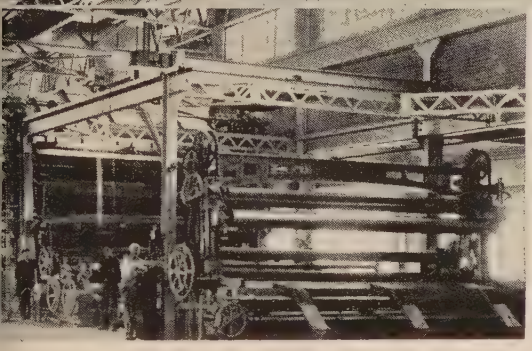
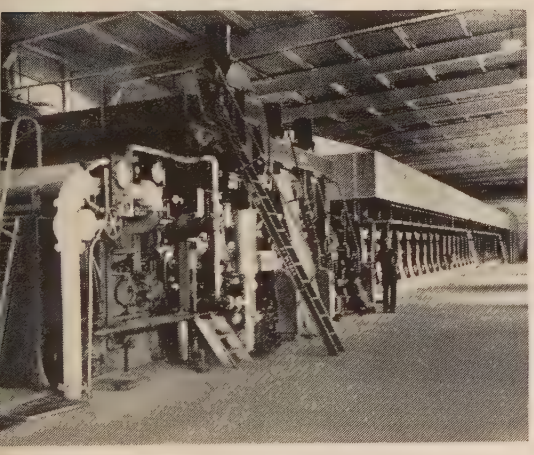
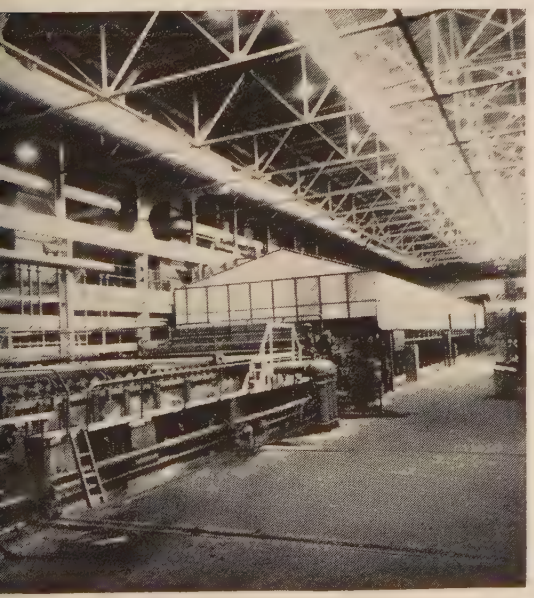


Typical Newsprint Machine



Typical Cylinder Machine



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purpose to Italians and other Europeans in marked contrast to the empty promises of Russian propaganda. And I am absolutely certain that the Marshall Plan bought the time needed by the Western European nations to establish the solid economic foundation on which to rebuild their military defenses, the beginning of which program took shape recently under the leadership of a great American in the Marshall tradition—General Eisenhower.

Technical Aid Program

The Technical Assistance Program of the Marshall Plan, staffed by technical men like yourselves, has been one of the most important phases of the American aid adventure in Europe. This technical assistance plan was evolved by Paul Hoffman when he was administrator, on the theory that a good look and listen around an American farm, factory, or union hall would do Europeans a great deal more good than voluminous reports and blueprints. Hoffman was right. The technical aid program is already paying handsome dividends. So many dividends, indeed, that President Truman, in his budget message, recommended that the interchange of technical personnel between the United States and free countries be continued and that most other aid funds be directed toward rearmament. The President pointed out that one of the strongest weapons in our arsenal is the technical know-how of our production people. It is a universal sort of weapon, which we can use ourselves or share with others. It is a most effective weapon because it is aimed against no other government or country but only against poverty and want.

I think that most of you will agree that few means of communication are so effective as personal contact. So it is in international affairs. Unhappily, it is impossible for all Europeans to come to America and for all Americans to go to Europe. The same is true of Americans and Asiatics. One of the next best means of communication is to talk to someone who has been, but preferably someone whose language is the same. By language I mean not just another tongue, but the thinking back of the semantics. For this kind of communication the interchange of technical personnel has produced excellent results. Technicians from, say, the machine tool industry in France, after having spent more than a month in America, have returned to France and have told their colleagues of the ways in which French machine tool builders can increase their productivity. Their observations receive respectful attention. Those who listen say "He was there, he saw what he is talking about, it must be so."

The product of this Technical Assistance program appears in many ways. An example can be cited in the visit of a paper production group from twelve European countries to American mills. Your courtesy and generous sharing of technical information went far to create a better understanding between our countries. So it went with other technical teams who visited in a variety of American industries. What amazed them most was the easy access to American know-how. Their amazement is not difficult to understand. Traditionally, business in the old countries has sheltered its processes from its competitors. This caution crossed the seas to America and it was only in recent years that there was any noticeable opening of American business doors to the public, or to a free exchange of technical information such as rather generally exists in TAPPI. This free postwar exchange of technical information between technical men who speak various tongues now shows up in Europe in the form of more shoes from assembly lines, more tons of coal per shift, greater yields of wheat, railroad trains moving on time, new systems of putting water on arid lands, better lighting, sanitation and working conditions for factory workers. In other words—higher standards of living.

Today Western European industry is operating at 140% of 1938 capacity. And that is an excellent record for it must be remembered that in 1944, after bombing, shelling, invasion, and sacking by the Germans, European industry was flat on its back. In France, for example, it was operating at 20% of prewar capacity. So it is important for the critics of the Marshall Plan to recognize that while the Marshall Plan helped with raw materials, machines, and technology, it was the Europeans who mined the coal, stoked the furnaces, loaded the pottery ovens, worked on assembly lines, and produced most of the foods. Spread over the life of the Marshall Plan, the $10 billion spent in helping European countries represents only 2% of the gross national product of the recipient nations. But our 2% made the difference between recovery—and Russia.

By-Products of the E.C.A. Visit

There have been some profitable by-products, too, from these visits of European technicians to the United States. Those who came to study methods of producing better goods at increased tempos saw more than the Statue of Liberty and tall buildings. They saw more than American machines and American methods.

They saw a generally fine working spirit between American management and American workers. They saw lively competition. They saw high production and recognized in it the priceless ingredient that has given American people their high standards of living and they returned home and told as many people as would listen about what they saw in America that was outstandingly different from old world ways.

When British labor management teams brought back to England their impression of the importance that is placed on higher productivity in the United States the British Trade Unions sent a special mission of their union officials to this country to talk to our labor leaders to find out if it were really true that American unions favored higher output; and how they reconciled this position with the fear of unemployment which has dominated the policy of many European labor leaders who look on increased production as good for the boss and bad for the worker.

One of the major human relations projects in Marshall Plan countries has been the establishment of faith in the minds of people who have become cynical from repeated wars—and occupations; the building of a deep understanding by those people in the honesty of America's purpose in their behalf. We have not been the equal of the Russian technicians of propaganda. So the challenge was to demonstrate that our purpose was good, and Russia's purpose was evil.

You may remember that Russia has been using every propaganda device to convince the wavering workers of Europe that American workers are slaves, chained to

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their machines. When I arrived in Italy to administer the Marshall Plan the Communists began using their newspapers, the radios, and the speaking platforms to declare that since J. D. Zellerbach had completed the job of enslaving his 12,000 paper mill workers he was now in Italy to enslave Italian workers.

This may seem laughable to us here in America, but if you and I were Italian workers who had suffered from wars and their aftermath, we likely would have been confused by the signposts of three years ago before the Marshall Plan set down its roots. We may have wondered which road led to the better life—the Communist blind alley or the American way.

When dealing with this great group of Italian people it is well to remember that the most effective Communist weapon in Italy has been, and continues to be, its autocratic control of the Italian Confederation of Labor. In 1948, this Red Confederation counted a membership of five million workers. Today that strangle hold has been broken.

Breaking the Strangle Hold

The breaking of that strangle hold was not accidental. It called for the best and most honest techniques in human relations. With encouragement of European Recovery officials and cooperation from American labor leaders, three Italian labor leaders crossed the Atlantic and visited American automobile, pulp and paper and textile plants in March, 1949. One of these labor leaders was Giulio Pastore, who had led one million members of his Christian Democrat union out of the Red Federation. The Italians' visits to American factories were under guidance of American labor leaders, among them Walter Reuther and Pacific Coast vice-presidents of the pulp and paper unions. With extreme caution, the Italians interviewed these American labor leaders on union organization and functions, then checked the answers with answers they received later from the rank-and-file union members.

Their caution went so far as to interview only rank-and-file members of Italian parentage in the plants. They asked about wages, grievance procedures, union dues, suggestion systems, working conditions, safety, and a host of related matters. They especially asked whether the workers are satisfied that the free American union labor movement is effective. There were a few lighthearted comments about the lack of shackles and chains, which brought hearty laughs from the American workers.

After work, the Italian labor leaders were invited to homes of the men they had interviewed. They were amazed to learn that the workers owned those homes and the cars in the driveways and garages. One worker told them he also owned the house next door, and that his son would soon be home from the mill with their second automobile. Pastore, on his return to Italy, commented in speeches and pamphlets that the only chains he saw in America were invisible chains binding workers to their unions, their jobs, their families, their automobiles, homes, electric refrigerators, radios, and other ownerships which would be regarded as fabulous luxuries in most of the best homes in Europe. At one meeting Pastore was asked what he thought of the lot of the American worker. He replied with subtle Italian humor—"the problem of the American worker is not whether he can afford to buy an automobile—his major problem is where to park it."

This was in late March, 1949. In May, 1949, the moderate Socialists and Republican leaders pulled out of the Communist Confederation to form a new group called the Italian Federation of Labor. This breakaway totaled 500,000 more workers.

Later this moderate Socialist and Republican group joined with Pastore's group to form a single free labor union movement known as the Italian Confederation of Free Labor Unions, with nearly two million members. This is another dividend from the dollars American taxpayers sent overseas, it has shown up in a marked weakening of Communist party strength; it will show up in attitudes of Italian workers called upon to produce the sinews of defense.

Opposition to the Marshall Plan exposes the Italian Communist party as the lackey of the Kremlin that it is, for it tried to stop American help—American wheat and coal and steel—from reaching Italy. Later the same Communist party attempted unsuccessfully to prevent American arms from reaching Italy. They wanted Italy to remain defenseless against Soviet or satellite aggression. This so exposed the traitorous nature of Soviet Communism that today we see the Italian Communist party itself split over the question of loyalty to Moscow versus loyalty to Italy.

Intrinsically, the aid which I have been talking about has cost the American taxpayer about 10 billion dollars. This seems a small price to pay for the security and time we have gained. For 10 billion dollars is the cost of slightly more than a month of war, at World War II rate.

Other Gains

What else have we gained by this expenditure? I hope we have gained the conviction that in a world crisis not only does Europe need our help, but, that we need Europe's. So one of the pay-offs then, is the strong foundation we have built overseas for the military assistance program which is vitally needed to protect our own freedom from extinction. Had we not been in Europe with the Marshall Plan these past several years, there would have been little substance or will among Europeans to resist invasion and no foundation on which to build defenses for peace.

We have all been somewhat confused by the great debate among outstanding Americans like Acheson, Dewey, Dulles, Hoover, Taft, and Truman. But as the debate proceeds one fact becomes increasingly clear—that is—that Europe is the balance of power between Russia and America. If Russia were to acquire the resources of Western Europe—its iron, steel, coal, power, agriculture—and the skills of her quarter of a billion people, Russia's industrial potential would exceed our own; and that, together with her present preponderance of manpower, would make our chances of successfully standing up against her next to impossible. It requires little imagination to envision the menace of a red horde, more numerous, better equipped and more venomous than the horsemen of Ghengis Khan; little imagination, then, to evaluate the results of the Marshall Plan.

I have tried to impress you with the importance of technical people, you along with the others, in this

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crusade for peace and freedom. Let me quote one well-known authority who agrees.

Sumner Slichter, Harvard University economist recently said: "Our conflict with Russia is not merely a competition in arms; it is fundamentally a contest in production—and a long-run contest."

If he's right—and I'm sure he is, then the technical assistance America has been given free European nations is the key to the success of our defense program. *It is the technique for freedom.*

If Mr. Slichter is right, then everyone of us in this room faces the challenge to apply his technical skills and experience to greater production of war essential materials—including, of course, pulp and paper—more tons of nitrating and other pulps from the same equipment, new and better types of product, and greater pulp yields from the same size woodpiles—increasing attention to forest protection and to restocking of the lands which we harvest. And there no doubt will be many among us who will be recruited for national duties outside our own industry. Wherever the responsibilities are, I know that this group before me and their associates back home in the mills, forests, and offices, will give a good account of themselves.

Someone has said that between the big things we cannot do and the little things we will not do, the danger is that we shall do nothing. The big and little things you technical men are capable of doing, for peace and for war, can put the United States in a position to lead the free nations of the world in the crusade for peace.

Address given at the annual luncheon of the Technical Association of the Pulp and Paper Industry, Commodore Hotel, New York, N. Y., February 22, 1951.

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Write for Bulletin No. 1400. It describes the motor-driven and hand-operated models as well as other Gurley paper-testing instruments. W. & L. E. Gurley, Station Plaza & Fulton Street, Troy, New York.

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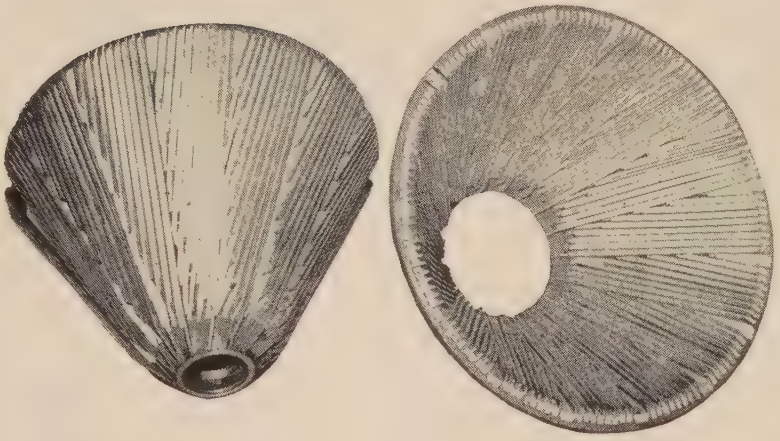

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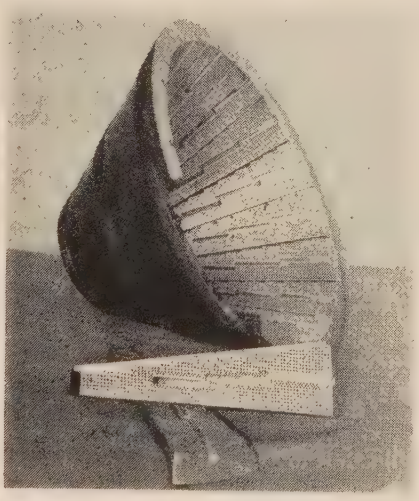

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The Paper Industry's Status in the Rearmament Program

LOUIS T. STEVENSON

It gives me great pleasure to be again talking to a TAPPI group. I well remember the first TAPPI paper I presented. It was in 1936 and the subject was the "Business Cycle and the Paper Industry." My interest in the subject has continued actively and my index of the basic demand for paper which was constructed for the APPA is a direct outgrowth of that original TAPPI study which I presented then. But enough of reminiscences, we have urgent present problems to consider.

No one knows the extent of the rearmament effort which will eventuate as a result of the decision of this nation to rearm. Present plans are subject to change, as of course they should be, depending upon day-to-day developments. Actions with far-reaching implications can occur overnight. There was a time last fall when it appeared that the Korean War was about to be closed out with a victory over the North Koreans. Then it appeared that the rearmament program would be carried on at a slow and steady marathon pace. When the Chinese first appeared in the conflict, the pace indicated was that of a quarter-miler. It has now speeded up to that of a 100-yard dash, and an even faster pace may be required by military, political, or economic events yet to come.

How does the rearmament program affect the paper industry? Before we get into the details of that, let us build a factual foundation with respect to where we are at present. "Let's look at the record," said Al Smith. Another less well-known worthy once said, "It's not ignorance that does so much damage; it's knowin' so darned much that ain't so." Therefore, let us see where we as an industry are now.

Production of pulp, paper, and board is the function of this industry. Let's see what has been accomplished in performing this function. I will try not to bore you with figures, but they are necessary to any measure of performance. I will take four key periods in this presentation, namely, the prewar year of 1939, the midwar year of 1944, last year, 1950, and October of last year in which so many records were broken. The record for these periods is shown below.

The clear evidence of these figures shows (1) production of paper and board increased by almost 30% from the prewar level to 1944, the year of greatest military activity in World War II, and this in spite of manpower shortages, and the complete elimination of 1,390,000 tons of overseas wood pulp from the United States pulp supply.

(2) The table also shows how this miracle of production was accomplished. (a) Canada increased shipments of wood pulp to the United States by half a million tons to almost double the prewar level. (b) Pulp production in the United States was increased by 3,100,000 tons, almost 45%. (c) The percentage of wood pulp was reduced from 64 to 61 in the over-all furnish, while the waste paper percentage was increased from 32 to 40% of finished production. These were the major contributing factors to that remarkable wartime record.

(3) Comparing now the years 1944 and 1950, production of paper and board has increased during this period by 7,100,000 tons or by 41%. Wood pulp production at the same time has grown by 4.8 million tons, or 47%. Canada has increased her exports by 55%, while imports of overseas pulp have expanded from nothing in 1944 to about half the tonnage shipped us in 1939. In the meantime, the over-all furnish has been enriched to 68% of wood pulp and waste paper has been lowered to 33%. Waste paper has returned to about its pre-War II relative status, while wood pulp has recovered all of its wartime drop in the over-all furnish and gained an additional 5 percentage points. The reason for this change is that the use of wood pulp grades of paper has grown so much more rapidly than the use of papers embodying rags, jute, straw, and other fibers, that the percentage of wood pulp in the over-all furnish has increased above the 1939 rate.

The last set of figures shows the peak of the industry operations to date, namely, during October of 1950. This is an actual record expanded to an annual rate. It is *not* an estimate of management based upon theoretical capacity. Paper and board was in fact 8½% above the 6-day week listed capacity, which indicates that about half the mills in the country were actually operating on a 7-day week.

These potentials show the ability of the industry to produce 26.5 million tons of paper and board and 16.4 million tons of wood pulp annually. Consumption of wood pulp in the production of paper and board was at the annual rate of 18,000,000 tons. These are actual capacities to produce and consume. Whether or not these capacities will be fully employed will depend

	Millions of tons			
	1939	*1944*	*1950*	*October of 1950 at annual rate*
Paper and board production	13.5	17.2	24.3	26.5
U. S. Production of wood pulp	7.0	10.1	14.9	16.4
Imports of wood pulp (Canada)	0.64	1.1	1.7	1.7[a]
Imports of wood pulp (Overseas)	1.39	0.0	0.7	0.7[a]
Total	2.0	1.1	2.4	2.4[a]
Supply of wood pulp	8.9	11.0	17.0	18.6
Consumed in paper and board mfr.	8.7	10.5	16.5	18.1
% of wood pulp to total paper tonnage	64	61	68	68
% of waste paper to total paper tonnage	32	40	33	34
% of other fibers to total paper tonnage	9	8	6	6
Total	105	109	107	108

[a] Estimated annual data are used.

Louis T. Stevenson, Economist, American Paper and Pulp Association New York, N. Y.

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largely upon the adequacy of future volumes of raw material, supplies, man power, and cost-price relationships.

All these in turn will be conditioned by present and future actions of NPA and ESA.

CONTROLS

Before we discuss the details of the present controls, it may be useful to review the history of pulp and paper industry controls in World War II. Time does not allow an elaborate and detailed review, but the following are some of the high lights.

During the early phases of the emergency planning of War II the essentiality and complexity of the pulp and paper industry were not fully realized. In fact, a plan for a drastic curtailment of production was drawn up in October, 1942. Although not adopted, the plan called for curtailment by steps to an eventual 10,000,000 tons annual production from the then current rate of 17,000,000 tons. An actual order "freezing" production at 100% of then current levels was issued in 1942, and in December, 1942, a series of orders limiting paper consumption was issued. The Army-Navy Munitions Board wanted curtailment of "nonessential" paper production to divert labor and materials to the production of munitions, planes, and ships.

Much of this attitude was due to misunderstandings, organizational difficulties, and lack of knowledge of the complexities of the industry.

A reorganization by which the Forest Products Bureau was formed and a closer coordination of effort was effected in the middle of 1943. Industry men were put in key WPB places and the emphasis placed on production. Then the industry was recognized as being essential to the war effort. Later, Donald Nelson, head of WPB, publicly acknowledged that at first the essentiality of the industry was not recognized, but eventually he had come to view it as among the most essential of industries.

We have been assured that under NPA the essentiality of our industry is recognized, and that production is to be encouraged. NPA has adopted substantially the same plan of organization which WPB eventually reached after almost two years of groping.

There is one major difference between the problems faced by WPB and its predecessors and those faced by NPA. At the beginning of the control activities for World War II, the country was just emerging from a severe depression, while in June, 1950, we were close to a peak in the business cycle. Industry was operating almost full blast on "K Day," June 24, 1950.

The result is that there is no slack to be taken up in the use of man power and plant capacity as there was in World War II. War production must now be imposed on a boom economy.

Probably the most far-reaching present problem is the tight supply of market wood pulp. Inventories have been scraping bottom for over a year while 1950 consumption of market pulp in paper and board increased by 25% over 1949. This tight pulp position has been reflected in the price levels of market wood pulp, finished paper and board, and waste paper. Prices of waste paper, always volatile, have shown spectacular increases since last July according to trade paper accounts.

Serious supply problems at the present time include copper for wire cloth (NPA Order M-12), and sulphur for the production of sulphite pulp.

Order M-12 has restricted the supply of copper for various uses including the manufacture of paper mill wire cloth. Wire manufacturers have filed individual appeals and the APPA has filed a statement with NPA. It is hoped that the result will be an adequate supply of wire cloth for full operation of the industry.

The supply of elemental sulphur to pulp mills has been reduced by sulphur producers. An analysis of the sulphur situation and recommendations have been presented to NPA authorities by APPA, and it is hoped to get relief from this limitation. The APPA has organized a special Committee on Critical Materials with appropriate subcommittees to watch developments as they arise and to take steps to protect as far as possible the interests of the pulp and paper industry.

A price freeze on the part of ESA appears imminent. The price level of the paper industry as shown by the APPA index of the average value per ton has followed closely the BLS wholesale commodity index, and this has mounted sharply since July. The BLS index has risen so sharply that a price freeze is threatened. In the meantime, the pricing standards request was issued by ESA in an effort to slow down the rise.

The priorities system set up in NPA Regulation 2 is adversely affecting the paper industry in two ways.

1. DO orders have been received by paper mills, creating confusion in scheduling and acceptance of business from regular customers. The industry has been advocating the issuance of a conservation order similar to WPB Order M-241. This worked during World War II and it is believed that issuance of such an order is imminent.

2. The pulp and paper industry is in need of priority assistance for its maintenance, repair, and operating supplies. This is particularly true in the metals field where war orders with DO ratings carry precedence over an urgently needed repair part that might hold up urgently needed paper for a war use.

NPA is working on this problem and we expect that this difficulty will be corrected in due course. In the meantime, mills that get up against this problem can apply to NPA for a specific rating.

No manpower action has yet been taken by ESA other than conferences with businessmen and labor leaders. Reports from Washington indicate the imminence of a wage price stabilization program. Nothing official has been announced at this writing.

The pulp, paper, and board industry is operating at record levels. It is faced with control problems which have already caused some slight curtailment. It is hoped to be able to meet these as they arise by Association action in cooperation with NPA. The National Production Authority has an announced policy of encouraging full production of pulp, paper, and board and, while there are threats to production on the horizon, I hope that NPA will be able to so handle its controls that production will be maintained.

RECEIVED Jan. 24, 1951. Presented at a meeting of the Delaware Valley Section of the Technical Association of the Pulp and Paper Industry, Philadelphia, Pa., Jan. 25, 1951.

Since the delivery of this address (a) the wire cloth manufacturers have received adequate allotments of metal for the first quarter of 1951, (b) ESA has instituted price and wage controls on January 25, 1951, and (c) Order M-36 has been issued by NPA on Feb. 8, 1951.

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Kamyr attacked the problem of pulp bleaching at a time when direct chlorination first made its appearance on an industrial scale. Until then progress had been by steady but slow evolution, but this process started a period of revolutionary development. Kamyr made its start by introducing specially designed circulation pumps. Special Kamyr items already in use throughout the pulp industry were ultimately to form part of the KAMYR BLEACHING SYSTEM.

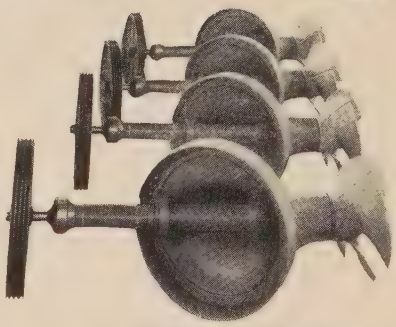
The soundness of Kamyr's theories developed and applied during these pioneering days has been proven by their adoption throughout the trade. Kamyr's emphasis on separate washing after each treatment, though long scorned, came to be accepted as standard procedure in *all* modern bleaching. The Kamyr vacuum washer meets any demand as to capacity, efficiency and resistance to chemicals.

Kamyr's solution for the efficient mixing and absorption of chlorine offers one of its strongest claims of superiority. Installation of a circulation pump at the base of the chlorination tower converts the bottom into a mixing chamber. The inlet and outlet of the pumps are connected tangentially to produce a strong horizontal circulation. The chlorine and pulp are thoroughly mixed. The pulp rises to the top of the tower and flows to the following washer.

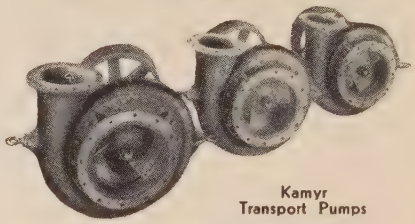
Pre-Impregnation Process

The Kamyr patented process for pre-impregnation at low density for high density pulp assures excellent impregnation thus producing a more uniform pulp, a higher alpha content and an increased yield. Sandy Hill's staff includes an engineer with more than 20 years world-wide experience in the Kamyr organization available for consulting services.

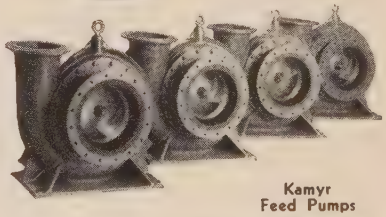
A brochure on the Sandy Hill-KAMYR bleaching process, just off the press, will be sent upon request.



Kamyr Circulation Pumps — Type CT



Kamyr Transport Pumps



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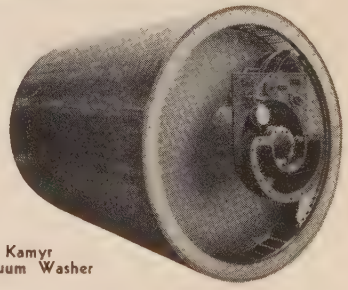

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REPORTS AND DISCUSSIONS

Presented at National and Regional Conferences

Condensations of Annual Meeting Papers

The following are condensations of a number of papers that were presented at the 36th annual meeting of the Technical Association (Feb. 19–22, 1951). Most of the papers will be published in full in subsequent issues of *Tappi*.

Controlling Stream Pollution in Pennsylvania, J. R. HOFFERT

This paper gives a brief history of the change in the legal control over stream pollution in Pennsylvania from the days of the Purity of Waters Act which was wholly in terms of sewage and protection of the public health, to the administration of the present antipollution law which provides adequate control, with penalties, over all types of pollution of waters of the Commonwealth as it affects not only public health but also water for domestic and industrial consumption, animal and aquatic life, and recreation. The progress is traced in control over industrial wastes from the days of limited voluntary and only partially effective cooperation by industry to the present time when through the authority of the Sanitary Water Board and real cooperation between industry and the Bureau of Sanitary Engineering of the Pennsylvania Department of Health, the investigatory and enforcement agent of the board, practical standards of typical raw wastes representative of reasonably good "housekeeping" by given industries have been adopted for some of the more important industries and other standards are in process of development.

The philosophy behind the adoption of such standards is explained, and Pennsylvania's board groupings or "classification" of streams as to their use and condition, the board's requirements respecting them, and the general policies of the board in dealing with stream pollution by both industrial wastes and sewage, are set forth. Some of the present-day thinking on the subject of various types of standards and their practical application are discussed, and the present and prospective public attitude and requirements as to stream pollution are considered.

The standards for raw wastes for pulp and paper mills, worked out in cooperation with the pulp and paper industry and adopted by the board, and the manner of their development and their use and limitations are briefly explained.

The paper outlines some of the great accomplishments already made in pollution abatement, stresses the public demand that our streams be properly protected and that in Pennsylvania there is a law to enforce this demand, but that it must be administered with equity and with due regard to all the factors involved.

Correlation of B.O.D. and Chemical Tests on Industrial Effluents, K. G. CHESLEY, R. W. WHITE, AND R. V. HOGG, JR.

Because of the length of time required to determine 5-day B.O.D. values, the possibility of calculating B.O.D. from oxygen consumed from permanganate and total solids values has been investigated. This study was made on the combined effluent from a kraft pulp and paper mill and a hardwood distillation plant. By the use of statistical techniques it was found that there is a significant correlation between B.O.D. and the other more rapid laboratory tests. The limits of accuracy for the calculated values were determined. With these established limits known it is possible to set up a control system that can be used with confidence.

Operation of the Bird-Gibbs Flotation Saveall, J. E. FITZGERALD

This machine is a development of the firm of F. S. Gibbs, Inc., in Boston. Basically the machine is intended for the clarification of paper mill waste water; that is, the removal of suspended solids. It is a high efficiency saveall operating on the flotation principle. There are three good reasons for its existence; namely, the widespread pollution of streams throughout the country, the appalling quantity of valuable stock that is now discarded in mill waste, and the desire of mills to reuse water.

The waste water is chemically treated with automatic control ahead of the machine. Subsequently, mixing, flocculation, flotation of the solids, concentration in removal of the floated material, and outflow of the clarified water take place in succession; all operations being integrated in a package unit. Flotation is induced by a pump set up outside the machine with its suction and discharge passing through the wall of the unit itself. This pump recirculates part of the clarified water. Installed in the suction line of the pump is a very special device through which the pump suction pulls a small amount of air from the atmosphere. This special assembly has the effect of breaking up the air passing through it into extremely fine bubbles, and intimately mixing them with the moving stream of water. This mixture is discharged within the main body of the unit. The tiny bubbles, in their upward passage, attach themselves to the suspended solids and carry them at quite a remarkable rate to the surface.

The first full-scale commercial installation of this unit is now in operation in a mill in Northern Massachusetts. Pilot plant operations are being conducted in several other mills.

Scott Paper Company Waste Disposal Plant, D. R. WADLEIGH AND L. G. SIMONS

Events leading toward installation of a waste water disposal plant at the Chester, Pa., plant of Scott Paper Co. are covered to show how the present plant was determined. Preliminary to filing plans with the State Authorities for a complete treatment plant for waste waters discharged into the Delaware River, the Scott Paper Co. conducted tests on a standard full-size precoat-type filter to obtain sufficient data for the design of a waste water disposal plant. Tests showed, for example, that the capacity of a Waco filter operating at top speed on paper machine white water having a fiber content of 8 pounds per thousand gallons was 600 g.p.m. but the capacity increased to 1400 g.p.m. when operating on lean waste water at 1.5 pounds per thousand gallons. Using the test results as a guide a complete waste water disposal plant was designed and built using Waco filters, and including a novel water collection system. The plant operation is completely automatic with a recovery of over 90% of the incoming fiber. The collection system consists of an elevated open flume which receives white water from numerous pipe lines fed by individual pumps. The flume conveys the water to a 100,000-gallon collector tank which serves to even out surges. Paper machine furnish is used for precoat and together with the recovered fiber is returned for utilization in the papermaking process. Actual operating records during the first 6 months show that filter performance has lived up to predictions based upon pilot plant studies.

Experimental Chemical Treatments for Kraft Mill Waste, WILLIAM MOGGIO

A review and description of the experimental chemical processes for the treatment of kraft mill wastes for removal of color and oxygen-consuming materials. The greatest disadvantage of all processes to date has been the excessive cost of treatment coupled with the problem of handling and disposal of large quantities of sludge produced. This probably accounts for the fact that none of the processes, with one exception, have gone beyond the laboratory stage.

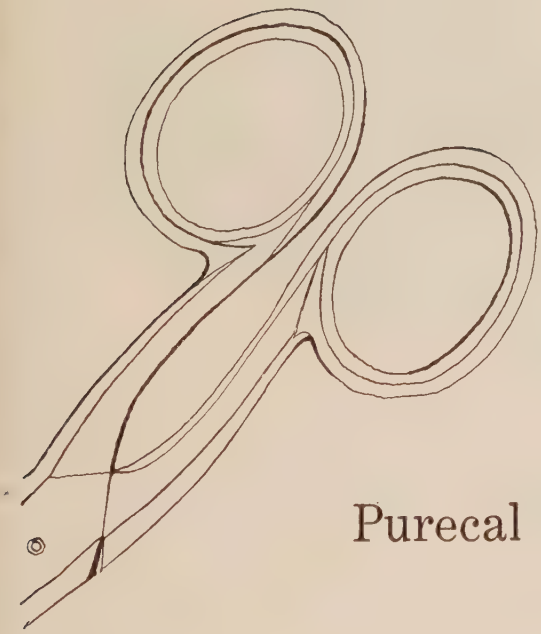
A chemical treatment process presently under study and development is described. The process involves the use of excess lime and carbonation followed by the recovery of the lime in the precipitated sludge. With the recovery of the chemicals this process shows promise of successful economic application. Methods of control and the development of an easily dewatered sludge are considered essential to success.

Light Reflection Measurements as Related to Decorative Insulation and Acoustical Products, RICHARD S. HUNTER

For individual measurements of the capacity of the surface to reflect light, conditions of measurement are standardized, both spectrally and geometrically. Two sets of spectral conditions are familiar to the paper industry: (1) luminous conditions corresponding to the eye response, with maximum weight given to the yellow-green region of the spectrum, and (2) blue-light conditions of paper-brightness measurement.

Geometrically, there are also two sets of conditions, used widely in the paper field: (1) 45° illumination, 0° viewing, typical of the geometric conditions under which materials are examined for visual color, and (2) 0° diffuse conditions, generally used by the illuminating engineer to evaluate the efficiency of surfaces as reflectors of light.

Ten or twelve different commercial instruments are used in the paper industry for measurements of light reflectance and other optical properties. They vary in cost from about $200 to $8000, as well as in the spectral and geometric characters of the measurements they make.



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Preservation of Fiber Insulating Board with Copper Pentachlorophenate, E. A. Behr and A. J. Hubert, Jr.

Fiber insulating board is subject to attack by fungi and insects but copper pentachlorophenate has demonstrated good preservation power. Since fiber insulating board mills are now using this compound for large-scale treatment of their product and more promise to be, investigation on the variables affecting retention was undertaken.

Copper sulphate, sodium pentachlorophenate (technical), wax sizing, and alum were added to a variety of board stocks, including aspen groundwood, southern yellow pine ground wood, Douglas-fir and western hemlock Asplund mixture, waste paper, and southern yellow pine Asplund pulp. Boards were analyzed for copper and chlorinated phenols. The most important variables, affecting retention are pH of the pulp chemical mixture and order of addition of reactants. The pH must be kept above 5.2 or low retentions result. If rosin sizing is added before the sodium pentachlorophenate and copper sulphate, copper resinate may form, and alum must be added last or sodium pentachlorophenate will precipitate. Only stoichiometrical quantities of reactants are needed. Retentions of at least 95% based on the theoretical retention resulted when the above variables were controlled.

There are two ways to effect addition of copper pentachlorophenate, the "internal" method in which reactants are added directly to the pulp slurry at an opportune point in the board manufacturing process and the "external" method in which the copper pentachlorophenate is formed in an external reaction vessel and added to the pulp as a suspension. Retentions are equally good with either method.

The recommended retention of copper pentachlorophenate to give good protection to the insulating board of 0.4% by weight. To achieve this retention, based on laboratory work, it would require 10.14 pounds of sodium pentachlorophenate (technical), and 3.94 pounds of copper sulphate pentahydrate to treat a ton of dry pulp.

Insulation Board Products and Their Relation to Various Building Codes, Charles M. Gray

This discussion consists of some history of building code legislation, the aims and objectives of a proper building code, the advantages of a modern performance code over the former specification type of code, a discussion of the four codes of national scope written and sponsored by the Building Officials Conference of America, the Pacific Coast Building Officials Conference, the Southern Building Code Congress, and the National Board of Fire Underwriters and the effort now being made to bring more uniformity in these codes through the Joint Committee for the Unification of Building Codes. Building codes are covered specifically in relation to insulating board materials. Some codes which regulate our materials in a proper manner and what the representatives of our companies can do in their local communities in an effort to obtain a good modern building code in any community which contemplates the adoption of a new code are mentioned. A portion of the talk will be devoted to the present wave of fire hysteria which is sweeping the country as a result of several tragic fires such as the LaSalle and Winecoff Hotels, the Effingham Hospital, and others, which has resulted in legislation being proposed or passed all over the country with unreasonable restrictions against combustible interior finish materials. The author will endeavor to present some logical facts which can be used in combating this fire hysteria and explain the program now under way in the Institute on this problem of interior finish.

Flame-Resistant Surface Insulation Board and Methods of Test, J. J. Perot

The expanded usage of insulating fiberboards in residential construction and remodeling together with the revision of building codes to provide more adequate protection against fire hazards render imperative the adoption of uniform standards and methods for measuring flame resistance of building materials.

This paper describes the methods now in use (commercial standard CS-42-49, Federal Specification SSA-118A, Underwriters' Laboratory tunnel test, room burn-out tests by Forest Products and National Fire Prevention Assoc.).

Large-scale experiments, such as room burn-out tests, must be made to provide realistic standards for life hazard. When this information is available, it is recommended that the Federal Specification Test SSA-118 be used for building codes and that the inclined panel test be used as a routine manufacturing control test.

Report on Insulation Board Institute Technical Committee Activities and Problems, E. M. Jenkins

The dissimiliarity between the normal activities of the TAPPI committees and the Technical Committee of the Insulation Board Institute is pointed out and illustrated by a review of present and past activities of the IBI committee. It is noted that TAPPI committees, as related to insulating board products, are principally connected with production while IBI handles primarily problems connected with distribution. The importance and wide variety of the IBI Technical Committee interests are outlined.

Report on Progress of Finished Products Testing Subcommittee and Future Program, Emile Frederick

The report of progress will concern: subcommittee membership changes during the past year; finalization and issuance of "Thermal Conductivity of Structural Insulating Board," TAPPI Tentative Standard T 1000 m-50; continued investigation relative to suitability of TAPPI Tentative Standard T 469 sm-45 "Flexural Resistance and Deflection of Fiberboard," for structural insulation; and the 1951 docket to be developed at February, 1951, Subcommittee Meeting.

Report on Progress of Raw Materials Testing Subcommittee and Future Program, E. M. Jenkins

A technique and apparatus for making test boards for the purposes of evaluating a fiber for use in insulating board has been worked out by the Raw Materials Testing Subcommittee of the Structural Fibrous Materials Committee and a suggested procedure submitted. Also, a technique has been selected and an apparatus designed for testing the freeness of insulating board pulps and a suggested procedure submitted. It is proposed to undertake research projects in 1951 to examine and establish advantages and disadvantages of the two suggested procedures by construction of the testing equipment and use of it in member laboratories and mills. A request for a research appropriation to obtain the freeness testing equipment has been submitted. A second request for board equipment will be prepared. Work will be begun on one new problem selected from the list needing attention.

Configuration and Structure of Cellulose Xanthate, Chian-Yuang Chen, Ralph E. Montonna, and C. S. Grove, Jr.

Freshly prepared and ripened viscose solutions were fractionated by the use of saturated sodium chloride solution. The ratio of sulphur to cellulose was estimated for each fraction. A freshly prepared cellulose xanthate of an average degree of substitution of 0.57 was fractionated into three fractions with degrees of substitution varying from 0.495 to 0.636. Another freshly prepared cellulose xanthate of an average degree of substitution of 0.427 was fractionated into four fractions with degrees of substitution varying from 0.379 to 0.474. Two ripened viscose solutions were fractionated under similar conditions. One sample was fractionated into six fractions which had about the same degree of substitution of 0.3. The other sample was separated into four fractions which had about the same degree of substitution of 0.22.

In the determination of the structure of methyl cellulose, the cellulose xanthate was prepared in the laboratory according to standard procedures and converted into methyl cellulose by treatment with nitrosomethylurethan at 5 to 8°C. for 5 hours. Glycol groups were estimated by oxidation of the methyl cellulose with sodium paraperiodate. Free glucose was determined by a yeast fermentation of the mixture of glucose and methyl glucoses which were obtained by hydrolyzing the methyl cellulose with 72% sulphuric acid. The residue from the fermentation was converted into methyl methyl glucosides. After distillation, mono, di, and trimethyl glucosides were calculated from methoxyl contents of the light portion and residue. Free primary hydroxyls were estimated by tosylation and iodination of the methyl cellulose. Free hydroxyls in position 2 were estimated from a rate curve which was obtained by the oxidation of methyl glucoses with lead tetraacetate. Free hydroxyls in position 3 were obtained by subtracting the glycol groups in methyl cellulose from the total glycol groups which were estimated by the oxidation of methyl methyl glucosides with sodium paraperiodate.

The most important results and conclusions are as follows:

1. The distribution of the xanthate groups among the cellulose chains in a freshly prepared viscose is uneven but the xanthate groups are more uniformly distributed in a ripened viscose.
2. The xanthate groups in neutral cellulose xanthate can be quantitatively converted into methoxyl groups under proper conditions.
3. The oxidation of glycol groups in methyl glucose by lead tetraacetate is a second-order reaction and the specific reaction rate of this reaction for the cis-glycol is about 100 times that for the trans-glycol. The specific reaction rate for cis-glycol, k_c, is 3.92 and that for transglycol, kt, is 0.0389.
4. Xanthate groups are uniformly distributed among the three hydroxyls in the glucose anhydride ring. The amount of dixanthate is very small in a normally prepared viscose and the trixanthate is almost nonexistent in the sample.
5. Summary of results on the determination of the structure of cellulose xanthate:

Average degree of substitution	D	= 0.721
Glycol groups per glucose unit	G	= 0.525
Free glucose	g_o	= 0.279

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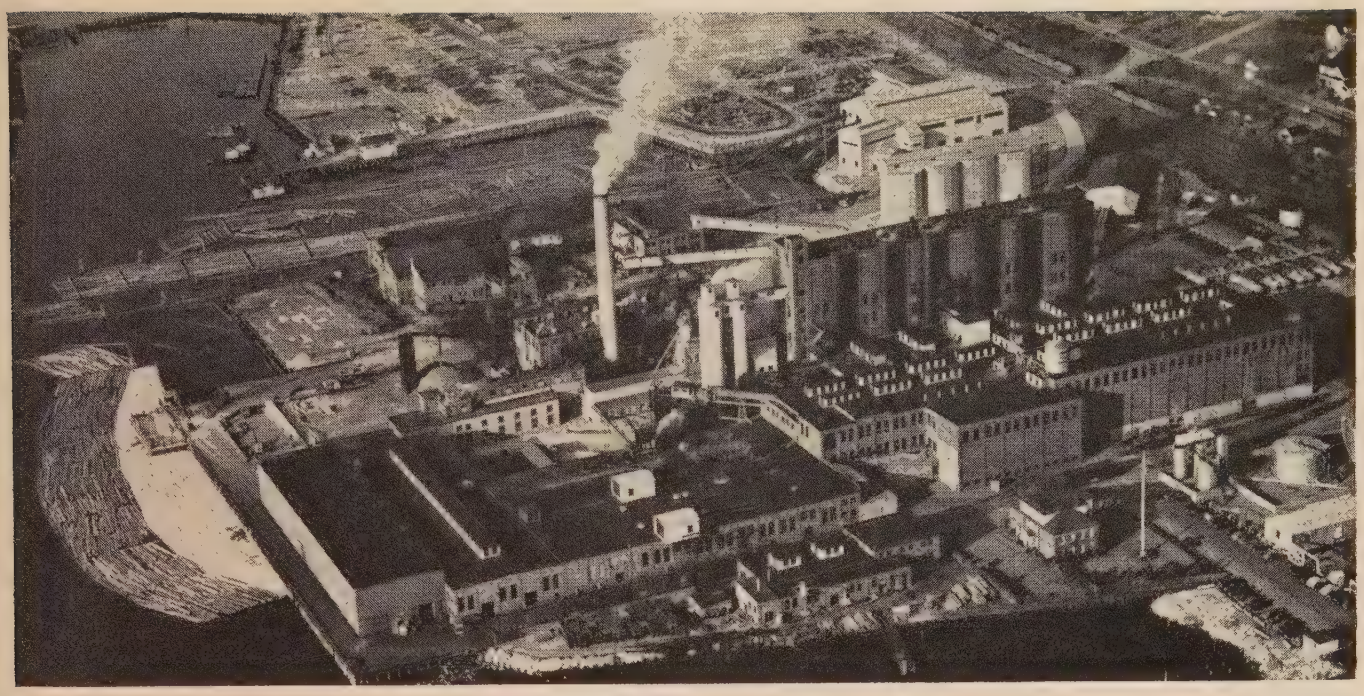

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Glucose anhydride 2-xanthate	C_2	= 0.270
Glucose anhydride 3-xanthate	C_3	= 0.208
Free glucose anhydride	C	= 0.279

The Bonding Strength of Certain Adhesives on Liner Board, Geoffrey Broughton and Ernest R. Kaswell

The Instron tensile tester, which is a constant rate of elongation electronic recording instrument, offers a new tool for the study of adhesive bonding. It has been applied to the study of corrugated board adhesion, opposite sides of the bond being placed between the opposite jaws of the tester. Amplified load-extension diagrams for silicate and starch adhesives are given and show strength as well as variability of the bond. The method has also been employed to study glue, starch, and silicate adhesives applied to uncorrugated liner board.

Redwood Plastic Pulp for Phenolic Resin Laminates, T. A. Howells and R. H. Goms

In view of the probable shortages of phenolic resins and of conventional pulps, a brief investigation was made of the effect of substituting low-cost redwood "plastic pulp" for one half the kraft pulp in a conventional kraft saturating paper. Handsheets made with 50% plastic pulp had lower tensile strength and poorer water absorbency than those made with all kraft pulp but the alcohol absorbency was not affected appreciably. Laminates made with the 50:50 furnish were weaker than those made with all kraft pulp but exhibited better bonding and better water resistance at comparable phenolic resin contents or equivalent bonding and water resistance at lower resin contents. The effects of drying or of degree of cooking of the plastic pulp were not as great as was expected from previous experience in other types of applications.

The Properties of a New Vinyl Chloride–Vinylidene Chloride Latex for Paper Coating, E. K. Stilbert and H. L. Clack

A new vinyl chloride–vinylidene chloride latex is described. The properties of this synthetic latex are outlined. Detailed information is presented on the methods of handling and formulating the latex to obtain useful decorative and protective coatings. Data on the properties of coated papers are presented which indicate that this latex will find wide use as a general purpose, vinyl resin coating material.

A review of the vinyl chloride–vinylidene chloride copolymer system shows that a latex based on a high proportion of vinyl chloride in the copolymer deposits films with excellent color stability, toughness, grease, water, and chemical resistance. It can be formulated to obtain a fair degree of moisture vapor resistance. Such a latex is being made commercially under the name, Dow Latex 744-B.

This new vinyl copolymer latex possesses excellent mechanical stability. It is widely compatible with water-soluble and water-dispersible materials. Since it does not form a film with simple air drying, special formulating steps are required to obtain useful films. Due to the excellent stability of the latex and compatibility of the polymer, excellent films can be obtained by using a wide variety of modifiers incorporated with standard mixing equipment.

The Properties of High Yield Kraft Pulps Produced at Bathurst, J. McK. Limerick

In a constant effort to conserve natural resources and at the same time obtain more production from a given quantity of wood, the Bathurst Power and Paper Co. have increased kraft pulp yields at 62% on a regular commercial basis. This has been largely brought about by brown stock refining according to the Sutherland high yield process which refines the pulp while still in the presence of hot black liquor after the blow tank and before the brown stock washers. The pulping process from the digesters to the machine room is described.

High yield kraft pulps representing current operating practice for linerboard with a yield of 62% and chlorine number of 16.2, and also pulp from a trial run of 64% yield and 19.2 chlorine number have been completely evaluated. They have also been compared with commercial pulp not produced by brown stock refining having a yield of 47% and chlorine number 2.9.

The high yield pulps were bleached in the laboratory (Bathurst does not bleach commercially) and produced bleached pulps at over 50% yield from the wood. The evaluations compared very favorably with a commercially bleached pulp.

Chemical analyses were done on all unbleached and bleached pulps.

High yield kraft pulps produced at Bathurst have high initial strength (due to brown stock refining). As the roughness increases they require more refining to bring them to a given freeness. The strength at any freeness compares very well with pulps of lower yield and good grades of kraft linerboard are being made from the pulp.

Summary of TAPPI Strength Tests

	At zero beating time			*At 450 freeness*		
Chlorine No.	2.9	16.2	19.2	2.9	16.2	19.2
Freeness	681	718	717	450	450	450
Time to freeness	0	0	0	49	69	116
Burst factor	32.1	36.1	69.6	94.4	90	98
Tear factor	250	155	128	113	88.5	89
Breaking length	7100	6120	9460	14,600	12,000	13,100

Rate of Beating of Prerefined Kraft Pulps, H. Wyatt Johnston and W. C. Lodge

Data are presented on laboratory beater tests of moist southern unbleached kraft pulp and the same pulp subjected to varied degrees of refiner treatment before beating.

Data are presented on laboratory beater tests of the same series of pulps that had been sheeted, dried, and stored before beating.

The maximum strength that can be developed by beater treatment is somewhat lower in the refined pulps than in the untreated pulp, whether they are dried or not before beating. The loss of ultimate strength tends to vary with the degrees of refining.

The average moist refined pulp is beaten to 450 freeness or 60 burst factor in approximately half the time required to beat the untreated pulp to the same degree.

The rate of strength development of both treated and untreated pulp is reduced by drying but the relative difference between the two types is substantially maintained.

Prerefined dried pulp may be beaten to a given strength (60 burst factor) or freeness (450 Canadian Standard) in slightly less time than the untreated moist pulp.

Prerefining appears to be of interest as a means of increasing beater room capacity.

Further Studies on the Alkaline Pulping of Scrub Oak, C. W. Rothrock, Jr., and W. J. Nolan

The effect of per cent sulphidity in the alkaline cooking liquor on the pulping of scrub oak (*Quercus lævis*) has been studied. Per cent sulphidity (grams Na_2O expressed as Na_2O per 100 grams total alkali expressed as Na_2O) was varied from 0 to 100%. Maximum strengths of pulps were found to result when sulphidity was held in the range of 30 to 45%. At sulphidities lower than 25%, pulp strength increased with cooking time. At 25%, strength of pulps cooked 1.5 and 3.5 hours total cooking time were about equal. Above 25% sulphidity, pulp strength decreased with cooking time.

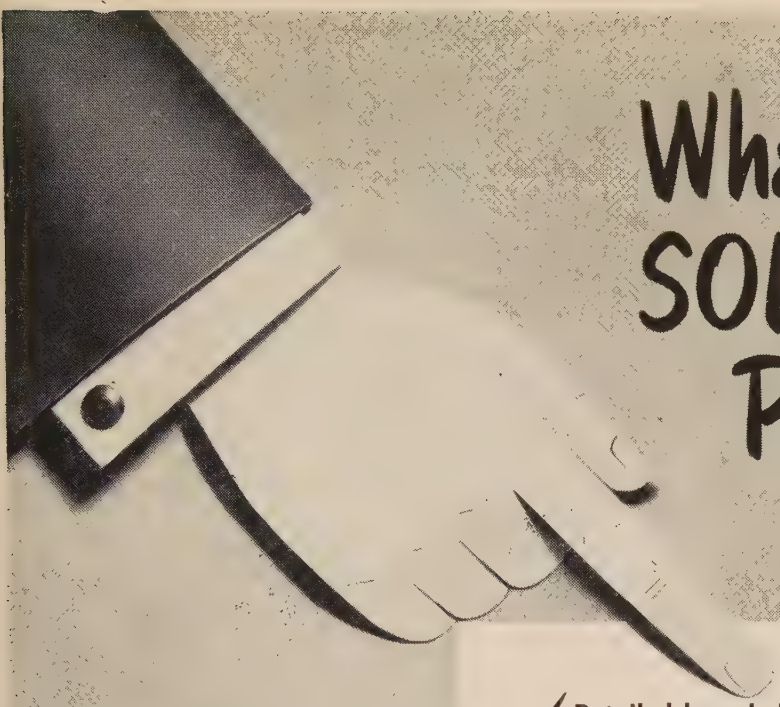
The easiest bleaching pulps were obtained in the same range of sulphidity as produced the highest strengths. Pulps with 46% yield and a single stage bleach requirement of 6.0% (75% G.E. brightness) were obtained in the range of 25 to 45% sulphidity. Permanganate numbers of pulps are presented but no correlation between permanganate number and bleachability could be found.

Addition of black liquor to the white liquor before pulping was found to greatly reduce the titratable sulphide in the cooking liquor. The same effect of high per cent screenings was found to result in pulps to which black liquor had been added as were obtained when low per cent sulphidity was used in the white liquor.

The best quality of scrub oak pulps, from a strength and bleachability standpoint, were found to result when 16% chemical, 35 grams per liter, and 30 to 45% sulphidity were used. Cooking pressure was 115 p.s.i.g., 1 hour to maximum temperature and 2 to 2.5 hours at temperature. Such pulps are well suited for use as filler or "soda" pulp.

Redwood as a Potential Source of Pulp, Harry F. Lewis

This paper summarizes a large amount of pulping research which has been carried out on virgin and second-growth redwood at The Institute of Paper Chemistry. It covers the amount, distribution, and nature of available redwood material, and the physical properties and chemical composition of the two types of wood. Experimental results of pulping by sulphite, sulphate, nitric acid, Asplund, and Masonite processes are discussed in some detail and possible uses of the resultant pulps summarized. A sizable amount of second-growth redwood is becoming available, and this material is potentially of interest as a raw material for pulping by the sulphate process. In addition woods waste and



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mill waste redwood can be converted by the Asplund process into highly desirable pulp for use in roofing felts and for other similar papers. Virgin redwood can be reduced by the sulphate process to give a satisfactory grade of bleached pulp; because of low yields such an operation is not currently attractive. Second-growth wood yields a strong bleached kraft pulp in good yield.

Some Factors in the Color Reversion of Bleached Secondary Fiber, H. P. Bailey, J. J. Forsythe, and E. F. Andrews

Secondary fiber obtained by deinking of waste paper tends to revert in color after bleaching. A number of factors involved in deinking and bleaching waste magazine stock were studied in the laboratory to determine their effect on color reversion.

Experiments with three different deinking agents showed that, in general, there was the least color reversion with peroxide, and the most with sodium hydroxide, with sodium carbonate being intermediate. Up to deinking temperatures of 160 °F. an increase in temperature resulted in less color reversion; a further raise in temperature above 160 °F. brought about slightly greater reversion.

In the bleaching operation, experiments were made in varying total chlorine, chlorine in the chlorination stage, and the hypochlorate. Increase of total chlorine and of the final brightness of the bleached stock gave less color reversion.

Buffered bleaching or high alkalinity in the hypochlorite stage gave higher brightnesses and less color reversion. It was found, under the experimental conditions observed, that hypochlorite bleaching at 110 °F. produced the highest brightness with greatest color reversion; that 140 °F. gave the lowest brightness with least color reversion, and that 80 °F. showed intermediate results.

The use of 1% caustic extraction stage decreased the loss of color. No further benefit was found in the use of over 1% caustic. Where peroxide was employed as an additional stage for final brightening, less color reversion was experienced.

Odor Elimination in a Sulphate Pulp Mill, P. Ghisoni, G. Bozza, and P. Colombo

Referring to a previous paper, in which the same authors have studied the possibilities of odor elimination through burning of gases in furnace, oxidation of combusted gases and effluents, and dispersion of smoke through a stack of considerable height, the practical results obtained after a year of application are discussed and criticized. In conclusion it is stated that it is possible to burn all the incondensed gases from digester relief and from the blow tanks in a normal furnace, providing that the velocity in the pipe be more than a certain limit value, that the gases be mixed with enough air to have a concentration below the explosive limit, that a good antiflame filter be provided before the inlet in furnace. Each device is in itself sufficient to prevent trouble, but the three together will give an absolute security of success. Oxidation of odorous effluents, using the effluents of the bleaching plant, gave very good results: on the contrary, oxidation of gases was found not necessary because the stack height is sufficient to guarantee dispersion below odorability limit (from 2 to 4 miles), according to the theoretical results obtained with the Sutton formula. The limit of 4 miles is sufficient to prevent settling of the fumes before dispersion and for this reason only seldom, and always in a very limited degree, odors are detected in this area.

New Developments in Starch Adhesives, J. E. Killinger

A new process employing a small percentage of alkali-setting resin is described for stabilizing corrugated starch viscosity. The stabilization process is carried on at the time the corrugated starch is prepared at the user's plant. Formulas are given for both regular and waterproof types.

The claims of United States patent 2,450,377 (Starch-Resin Reaction Product and Method of Producing Same) are discussed and the advantages which may be realized in waterproof corrugated starch adhesives are disclosed. Formulas used in commercial practice are set forth. Condensations of ketonic, resorcinol, and other alkali-setting resins with corrugating starch are discussed and their present limitations cited. Some reference is made to the possible interference borax with satisfactory condensation between resin and starch.

It is further suggested in order to realize higher production speeds that starch-ketonic resin adhesive be used on the double face side and starch-urea formaldehyde resin adhesive be used on the single facers.

Laboratory work done with corrugating starch on PVA for producing waterproof adhesives are discussed. Formulas employing starch, PVA-bearing adhesives, ketonic, and urea formaldehyde resins are given.

An application of corrugating starch, either regular or waterproof, together with other sizing ingredients is discussed for applying to the corrugated flutes prior to the time the double back liner is attached. The discussion also includes comments on applying the same type of sizes to the single face web prior to joining the single face liner and with reference to the addition of the size to the inner faces of one or both liners. Remarks are made with reference to increase in flat crush and compression tests at regular humidities and at high relative humidities as well as to the possibility of this or a similar process for improving the water resistance on the single face bond.

Starch Urea Adhesives, E. S. Gantt

The shortcomings of the weatherproof corrugating pastes made with the urea formaldehyde resins have been pointed out and discussed, and the best of this type of corrugating adhesive formulation is defined and described. The use of the acid curing urea formaldehyde resins precludes the desirable inclusion of caustic and borax in the corrugating formula. Because of these omissions, less water must be used in the urea formaldehyde paste formulation to maintain the adhesive at a machinable viscosity.

Best results are attainable with this type of formula when a small amount of caustic is cooked in the carrier, 10% resin is used in the suspended portion, and the pH of the final mix is adjusted to 5.0 to 5.5 with either alum or ammonium chloride.

Two types of resin additive that necessitate no change from the standard formula containing $2^1/_2$% borax and $2^1/_2$% caustic to provide water resistance have been investigated. Both of these, the ketone-formaldehyde resins, and the resorcinol-formaldehyde resins, have shown considerable merit for this type of operation when used with equivalent amounts of formaldehyde.

Considerable field work remains to be done in testing both the ketone and resorcinol resins in application. It has been generally found that the results are quite satisfactory on the double-backer but that satisfactory waterproofing is not obtained at the single face liner. The addition of formaldehyde with the ketone resin has given sufficiently satisfactory results to warrant its trials commercially.

Improvement may also be obtained by mechanical means such as suspending a canvass or piece of old belting over the single face board between the corrugator and the bridge and possibly introducing a steam shower at this point to provide additional heat and time for curing resin.

PVA Adhesives, E. G. Boyce

A vinyl base adhesive, such as DuPont Adhesive No. 77, provides an adhesive for specialized or intermittent use for making weatherproof corrugated board with a minimum of preparation and specialized equipment. Certain operating practices must be followed to assure the production of well-bonded board. The higher cost of this type of adhesive means that its greatest and general field of use will continue in the solid fiber and specialty laminating fields where its operating characteristics are outstanding. More widespread use in the corrugated board field can be predicted with future developments that tend to lower unit consumption of adhesive and provide additional improvements in bonding characteristics for this particular operation.

Silicate Adhesive for Weatherproof Corrugated Board, R. L. Kreyling

Alkaline silicates react with vegetable protein to produce moderate length amino chains and polypeptides. Upon heat setting, these form cross linkages with resulting molecular growth sufficient under proper conditions to produce water-resistant conglomerates. Limited observations indicate 1 part protein to 2 of silicate have very limited working life but good dry bond, excellent wet bond, and good absorption of silicate alkali. Mixtures containing 1 part protein to 5 of silicate have stable life, provide good, dry bond, satisfactory wet bond, and absorb enough alkali to reduce desizing. Further practical experience is needed.

Calender coating of the board with various acidic salts will completely eliminate any alkaline desizing. Addition of resins effective at alkaline pH's ultimately polymerize and provide increased water resistance but are costly.

Commercial Testing, C. J. Zusi

An important part of the difficult process of producing weatherproof corrugated boxes is the continuous checking of quality by means of the regular performance of tests in accordance with the specifications of the armed forces. The data so obtained enable manufacturers to correct defects at once and to determine quickly those changes or modifications in processes which result in improved quality. The tests used are caliper of facings, normal bursting, bursting after 24-hour immersion, separation of plies after immersion, and wet drop tests.

Quartermaster Inspection and Testing, Major R. E. Willett

The function of Quartermaster inspection has been aptly characterized as "the quality watch dog of procurement."

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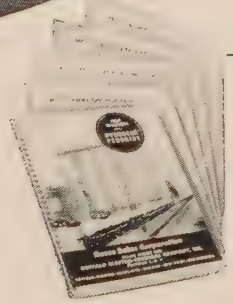
Upper bleach liquor distributor pipe

Upper nylon brush for spreading liquor



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and Oakland, Calif.; a General Testing Laboratories Division at the Philadelphia Quartermaster Depot; a Subsistence Testing Laboratory branch of the Chicago Division, and groups of inspection representatives at all Quartermaster Centers except Williamsburg.

These components act as impersonal enforcers of Government specifications and thereby guarantee that Uncle Sam receives that for which he has contracted.

Through the use of Standard Inspection Procedures, calculated sampling plans, and uniform inspection tools, the inspection is reduced to almost an "exact science" to eliminate partiality and nonuniformity of decisions.

Turning now from field inspection functions to laboratory testing, we may consider the evaluation of weatherproof corrugated board.

If the material is intended for purchase and use by the Government itself, it will be tested as a so-called "end item." However, when the material is being used by a contractor for packing any other Government purchase or end item, it will be tested as a packing component.

The procedures and requirements in either case are nearly identical, with two main exceptions. As an end item, a Standard Inspection Procedure, or S.I.P., is used in conjunction with the specifications for the weatherproof corrugated board, which is Joint Army and Navy Specification Jan-P-108. The S.I.P. prescribes the tests in the specification to be performed, and the number of determinations and tolerances for each. As a packing component, however, the S.I.P. does not apply; and the requirements are taken from Jan-P-108 directly. Of course, the type and grade of the material will be determined from contract stipulations if it is being purchased, or from packing instructions in the contract or in the end item specification if the material is a packing component.

The first step in the laboratory evaluation is to determine the applicable tests and requirements from the specification and to record them upon the laboratory report.

Panels measuring 6 by 10 inches are then cut from the boxes and conditioned for at least 4 hours at 73 °F. and 50% R. H.

One panel from each box or sample unit is submitted to the chemical laboratory for 24-hour tap water immersion.

Another panel from each set is partially separated into its three plies with a sharp knife or razor blade, after which the thickness of each of the two liners and of the corrugated material is measured with a machinist's micrometer.

The dry bursting strength or Mullen of another panel from each box is then determined. The bursting strength requirements for V3C, W5C, and W6C boards are, respectively, 400, 275, and 175 p.s.i.

As a packing component, the panels are required to have a stipulated number of flutes or corrugations per foot, but the S.P.I. eliminates this requirement when the material is being tested as an end item.

After the other panels have been submerged in water for 24 hours, they are taken out and examined for ply separation on the edges and other areas. The maximum permissible ply separation on the edges is 1/4 inch, and no separation is allowed in other areas.

These same panels are then tested for wet bursting strength. The minimum wet bursting strengths allowed for V3C, W5C, and W6C boards, respectively, are 150, 100, and 50 p.s.i.

The tests after water immersion produce the largest proportion of rejections, and it is this quality of strength retention after water immersion which makes the material particularly valuable, providing a relatively lightweight packing container that will hold together when thrown into the surf, or stored in the hold of a ship flooded to prevent fire, or subjected to continual deluges of tropical rainfall. This quality earns it the title of weatherproof board.

Weatherproof Corrugated Board Operating Problems, J. J. Koenig

Basic influencing factors in the operating problems of weatherproof corrugated board manufacture are: (1) adhesive characteristics, (2) component board properties, and (3) corrugator (machine) conditions.

The problems due to adhesive characteristics have been greatly reduced since the early days when it appeared customary to use weatherproof adhesives with very high resin content in a reactive state that required close technical control to prepare and use.

The major part of the adhesive handling problem has been solved by the development of weatherproof corrugating adhesives now available which are easily prepared and which have good stability.

The principal adhesive handling problem remaining is encountered when the corrugator operators switch from running regular board with regular alkaline adhesive to weatherproof board requiring weatherproof adhesive. None of the regular alkaline adhesives is compatible with the various known weatherproof adhesives, and therefore, when the switch is made, it is considered the best and safest practice to thoroughly wash the entire circulating system clearing it of regular alkaline adhesive before filling it with weatherproof adhesive.

Control and prevention of dry streaks in the glue applications on both the single facer and double backer sides is another problem relating to adhesives. Proper control of these streaks involves adjusting the adhesive viscosity to fit individual machine conditions.

Weatherproof board components are, by their nature, more difficult to fabricate than regular grades of board. The main difficulties are those affecting running speeds.

At times, excess moisture in the components occurs intermittently or in streaks, and it tends to cause loose corrugations or blisters. The effects of this trouble have been partially remedied by increasing the preheating of the liners.

The problem of attaining maximum possible running speeds has been helped by the use of large preheaters on the liners and on the single faced board just before it enters the double backer.

Damage to the board during fabrication can happen at any of the usual points of pressures and stresses in the process.

Continuous cooperation between the material suppliers and producers of weatherproof corrugated can be expected to lead to many further improvements in the art of producing weatherproof corrugated board.

Problems of the University Placement Director, Gordon G. Sikes

A company wishing to hire college men may contact them by: (1) sending a representative to the college, (2) correspondence, and (3) receiving applicants at company office.

Actually all of these methods are used in normal recruiting procedure:

College calendar and daily schedule, recruiter's schedule, business requirements, dead lines, arrange visits well ahead, at least two weeks in advance of actual visit.

Report to student within agreed time—say two weeks after interviews and keep placement office informed (carbons of all correspondence). Arrange candidate's visit for second interview at mutual convenience and inform him whether or not his expenses will be paid (but no entertainment).

Complete information beforehand to placement officer (blanks, information sheet, printed matter); during interview give adequate description of work, opportunities, advantages, and disadvantages.

Companies should visit campuses regularly—lean years as well as good—and should select with care the institutions to be visited; then trust the placement officer's recommendations after mutual confidence has been established. Also companies should select with care their representatives and see that they can represent and discuss intelligently the company as a whole as well as their own department. *Keep on schedule.* Avoid special and unusual arrangements unless planned ahead. Does the recruiter handle equally well candidates who are (1) shopping around, (2) genuinely curious, and (3) genuinely interested?

The Chemical and Metallurgical Program of the General Electric Company, Robert R. Ralston

For three-month work assignments for newly graduated chemists, metallurgists, and chemical engineers form the basis of a training program designed to give the new employee a chance to get a broad acquaintance with the company's organization and its opportunities. In addition a course of classes in advanced process technology is offered to stimulate original thinking. At the conclusion of the program, the trainee is encouraged to express his preference for permanent assignment based upon acquired information rather than upon preconceived and often erroneous ideas of industrial opportunities.

New Employee's View of Industrial Training, F. P. Nuelle

A member of General Electric's chemical and metallurgical program relates his own experiences and observations thus far on the training program, and how he and other trainees have benefited personally and professionally by training program experience.

A Short Program for the Orientation of Technical Employees in the Chemical Industry, O. A. Greiner

The recent college graduate very seldom has had the opportunity to find out how industry works. It is important to make his introduction to industry a pleasant and instructive experience. At the same time the company can take advantage of this opportunity to evaluate the new technical employee's potential more completely than was possible during the original selection program. The manner in which these things are accomplished is discussed. Also, the purposes of having a program are outlined. The program described is that which is in operation at the American Cyanamid Co.'s Calco Chemical Division's main plant at Bound Brook and which is the outgrowth of experience gained over a period of 18 years.

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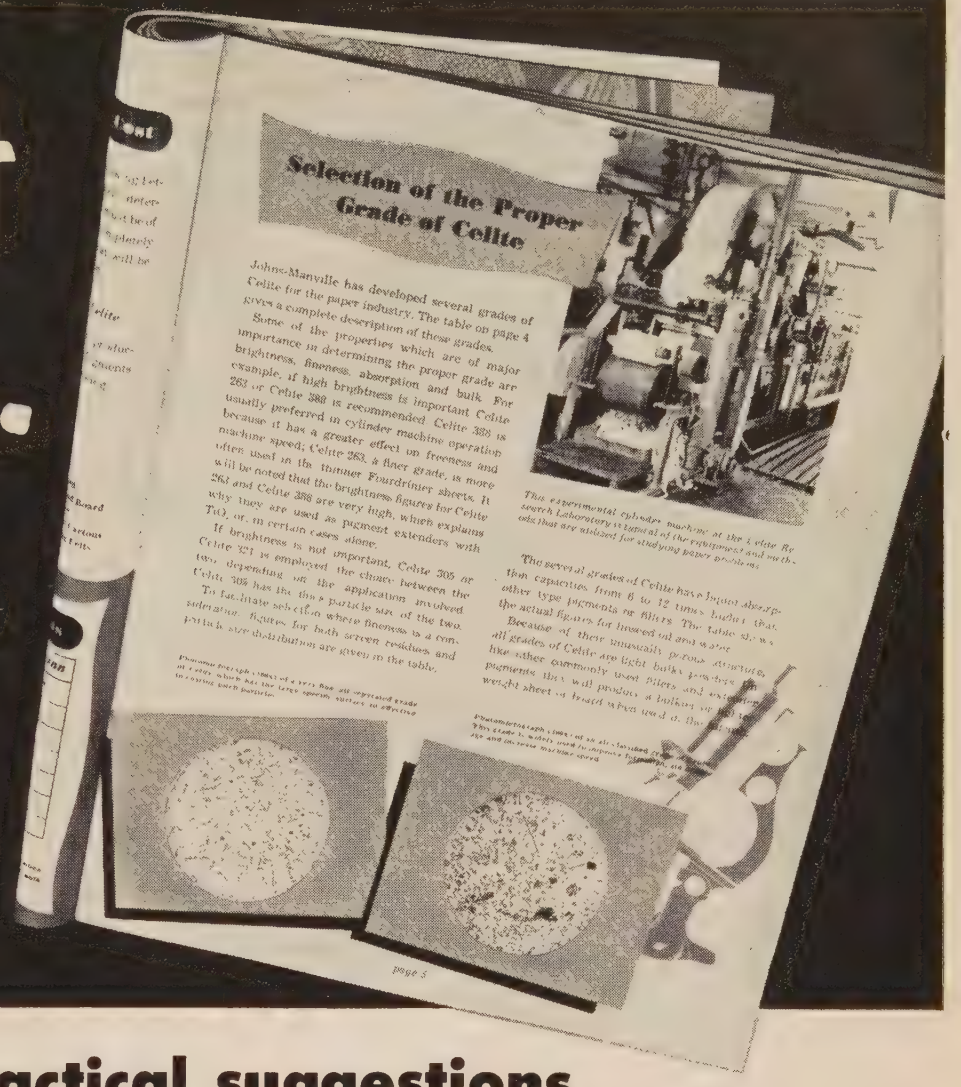

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A Young Engineer Looks at Industry, Seymour J. Rose

The young engineer early forms definite impressions of industry. He formulates what he considers to be the ideal conditions of employment based upon early ideas and the conditions he encounters.

Generally, there are six conditions which he considers as most necessary to happy employment. These are: (1) a clearly defined and rigidly adhered to personnel policy, (2) a comprehensive training program, (3) periodic evaluation of the employee and his supervisor, (4) merit rather than seniority advancements, (5) sound retirement and hospitalization plans, (5) an organized extra hour social and athletic program.

These conditions were the unanimous choice of almost 100 young engineers polled, and the talk outlines particular practices considered by the engineer newly entered into industry.

The Mechanical Behavior of Paper—Part I, Geoffrey Broughton and N. A. Matlin

Much work has been done in the past on the mechanical behavior of paper, including its stress-strain behavior. In most cases, however, rate of elongation was not constant.

In the present investigation, load-elongation curves were measured at constant rates of elongation, varying from 0.02 to 2 inches per minute, using the Instron tensile tester. Results are presented for a number of different papers, including handsheets and machine-made papers.

The data have been studied and some tentative correlations are presented.

The Mechanism of Fiber Bonding, W. S. Wilson

Extensive use of the wet break test showed a remarkable agreement between the shape of these curves and the shape of water pickup against time curves for the same sheets. Very large changes in sizing caused very great changes in the shape of the wet break curve. These changes were always duplicated in the shape of the water pickup against time curves. Since the units were breaking weight in one case and per cent water pickup in the other, the agreement was in principle only. In the hope of explaining this agreement, a study of the mechanism of the wet break test was undertaken.

The effect of sizing, wet strength resins, and wet strength from dry heating on the wet break test was studied. Studies of increased stiffness and constant relative increase in wet break test with heating on two freenesses of pulp led to the belief that the strength of paper is practically purely mechanical.

Very rough stress-strain data are introduced to strengthen the above assumption. Some density versus dry strength curves where density is varied by both beating and increased surface tension are presented. These curves on four different pulps meet the expectations of the mechanical theory and may indicate two heretofore unconsidered variables in pulp. The author's theory is that the flabbier a pulp becomes on beating, the more it can crimp under a given pressure during sheet formation. The stiffer the pulp becomes on drying, the harder it is to uncrimp under stress and the stronger the sheet.

Effect of Urea and Related Compounds on the Mechanical Properties of Paper, Henry D. Fisher

The plasticizing action of ureas and formamides has been definitely shown to be due to the effectiveness of the plasticizer molecules themselves, and not to any hygroscopic characteristics of the materials. A study of the effect of ureas and formamides on the load-elongation properties of an alpha sheet has shown that, like water, these materials reduce the tensile strength and elastic modulus of a sheet while enhancing its ability to flow under stress. The urea type of plasticizer has been shown to form bonds with the cellulose—probably hydrogen bonds between the urea carbonyl group and the cellulose hydroxyl groups. The formation of this bond is believed to satisfy reactive hydroxyl groups on the cellulose which would otherwise be involved in moisture sorption, so that one of the effects of the initial increments of a urea additive is a reduction of the moisture content of the sheet.

The effectiveness of the urea plasticizers is probably due to their ability to reduce in number and strength the secondary cohesive forces which are largely responsible for the mechanical strength characteristics of the fiber-to-fiber bonds and the fibers in a sheet. The presence of these additives in the cellulosic structure is believed to maintain the cellulose in a state of dry swelling by a mechanical separation of cellulosic chains or chain bundles. The importance of the molecular size of the plasticizer molecule in determining its ability to prevent the deswelling of the cellulosic sheet on drying has been demonstrated. In addition to its effect on the manner in which a sheet reacts to stress, urea has been shown to reduce the shrinkage forces set up in a sheet during drying.

The Preparation and Properties of Periodate Lignins, Manning A. Smith

Periodate lignins have been prepared from cottonseed hulls, buckwheat hulls, and corn cobs. The properties of these lignins have been compared with black spruce periodate lignin. Observations made during the course of these preparations have led to some modifications of the original process.

Several experiments have been carried out on spruce periodate lignin with the idea of obtaining some information relative to the validity of Alfred Russell's proposed formula by gymnosperm lignin. Evidence of a carbonyl group has been obtained through the preparation of a product from hydroxyl amine and lignin. This material, presumably an ozime, contains 28% nitrogen. Evidence of an active methylene group next to the carbonyl has been sought in reactions of the lignin with *p*-chlorobenzaldehyde and with amyl nitrate. Neither of these reactions has successfully demonstrated the presence of such a group.

Slices, Paul Boronow

The author presents an illustrated discussion of the various types of slices built by Valley Iron Works Co. describing the substantially different treatment required by various fields of papermaking. This is followed by discussion of certain questions, such as: desirable positions for slice distributing rolls, the effect of a plurality of distributing rolls in the headbox prior to the slice, the effect of different relationships of the upper slice lip and apron in relation to the breast roll center line, the degree of adherence by mills to theoretical head carried behind the slice in relation to wire speed, and general information relative to keeping slices in good operating condition.

Statistical Techniques in Maintenance of Testing Instruments, W. Edmund Patte

The problem of maintaining a large number of testing instruments in the laboratories of an integrated mill is discussed. The location of testing instrument maintenance in the technical organization is described. The use of edge-punched index cards for indexing of maintenance information and a method used for keeping instrument histories are illustrated. The use of reference paper for weekly checks of primary paper tests is described and the calculation of "action limits" for withdrawal of instruments from use is detailed.

Case Studies in the Application of Industrial Statistics to Papermaking, Charles A. Bicking and Richard T. Trelfa

Five case studies of actual applications of industrial statistics to papermaking which describe control activities at a very practical level are included.

The first explains how control charts were used to reduce variation in basic weight across the paper web as well as in the machine direction of the paper sheet.

The second covers the use of frequency distributions to analyze and portray changes in basis weight and headbox freeness.

The third case study describes the use of significance tests to measure and improve the precision and accuracy of two analysts using greaseproof test data.

The fourth uses control charts to demonstrate how the number of errors made by paper sorters was drastically reduced.

The final case study employs the analysis of variance technique to investigate paper testing technique with the purpose of improving critical factors in the water penetration test. Four testers and eight different papers were involved.

Each study includes presentation of all the original data, description of the method of statistical analysis, and careful summarization of the interpretation, action taken, and results. A list of references is included as well as a statistical appendix which shows all the computations involved in each study.

Nomographic Assistance in Statistical Calculations, W. E. Patte

This paper submits two nomographic charts to facilitate common calculations in industrial applied statistics.

The first chart enables the precision of an average to be estimated graphically from the number of individual results making up the average, and the range or spread, of the individual results. A tolerance e, is thus obtained for the observed average X, so that the "true" average may be expected within the interval $X \pm e$. This precision, $\pm e$, is associated with reliabilities of 95 or 99.9% according to the scales utilized on the chart.

The second chart solves graphically the common equations in statistical control work. Included are the relationships of average and extreme ranges displayed by groups of results to the standard deviation of the individual results, and of the standard deviation of individual results to the standard error of averages, for groups comprising up to 15 individual results.

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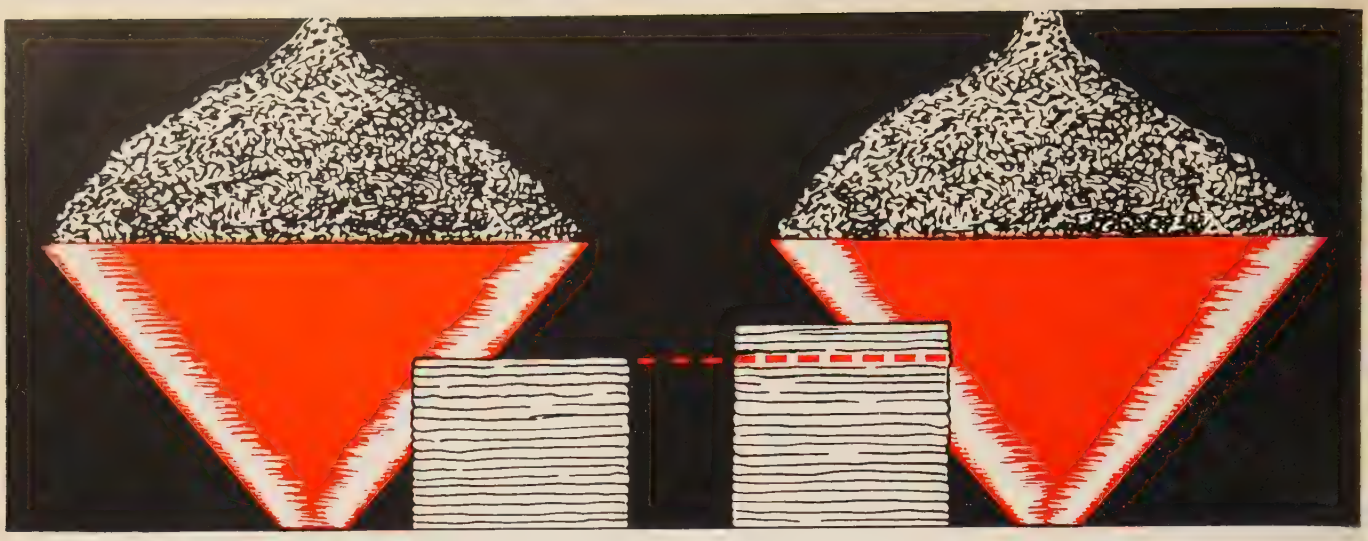

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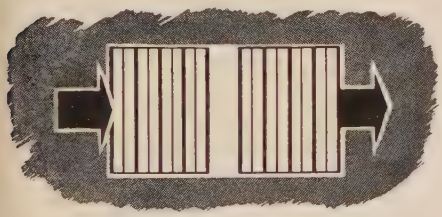
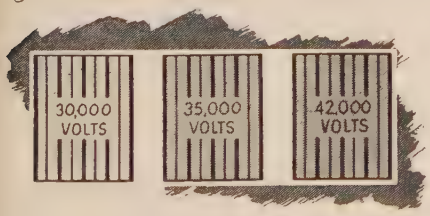


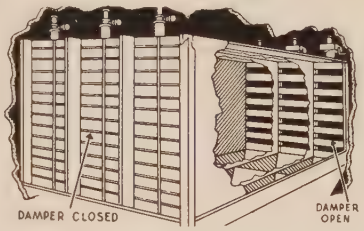
2 **Higher Recovery:** The horizontal flow design of Western Precipitation COTTRELLS eliminates collected material falling countercurrent to incoming gas stream. This assures higher recovery, minimum resuspension of recovered material in gas stream.



3 **Maximum Performance:** Horizontal flow of Western Precipitation COTTRELLS permits use of multiple electrical sections so that voltage in each section can be varied to dust loading for maximum recovery without arc-over or electrical breakdowns.

4 **Lower Over-all Cost:** When comparing COTTRELL costs, be sure to compare total *installed* cost, including duct work.

5 **Simpler Maintenance:** Because all interior parts and electrode systems are readily accessible, Western Precipitation COTTRELLS are far easier to maintain and service. Saves "down" time, saves repair costs.



6 **Greater Adaptability:** Horizontal flow design permits use of multi-vane dampers in multiple-unit installations. Thus, one unit can be shut off completely to permit maintenance operations without closing down entire Precipitator. Also, the dampers can be used in slightly-closed position to assure more uniform gas distribution.
On single-unit installations, chain curtains assure uniform distribution of gases. Curtains are easily kept clean by shaker mechanisms provided.

7 **"V"-Shaped Hoppers:** Horizontal design permits use of continuous "V"-shaped hoppers for collecting recovered material. Steeply-sloped walls in this type of hopper prevent build-up or bridging of recovered material.

8 **Space-Saving Compactness:** Not only do their horizontal design permit maximum compactness in Western Precipitation COTTRELLS, but various sections of a unit can be arranged for indoor installation in space above cascade evaporators, thus utilizing space otherwise wasted.

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The Calculation of Mullen, Edward R. Hoffman

With the advent of statistical quality control to a paper mill, the preparation and maintenance of many control charts for the properties of the grades manufactured become a problem. One chart may be used for each property when data are transposed to hypothetical values based on a standard grade of paper. The method is illustrated by Mullen data and consists of graphically establishing the relation of Mullen to the weight of the paper and the various constituents of the furnish. The data are then adjusted mathematically to values which would have been obtained if the paper machine had been manufacturing one grade and weight of paper. The resultant chart may then be used for the study of paper machine performance, beater-standardized beating procedure.

Groundwood Bleaching Variables, a Statistical Approach, F. R. Sheldon

The bleaching of groundwood pulp with hydrogen peroxide is cited as an example of a complex system upon which statistical methods can be used to advantage. A short outline is given of the many variables believed to be important in peroxide bleaching. The interdependence of these variables is indicated, and statistical tools for estimating the importance of the variables and their interactions are discussed.

It is suggested that a combination of two statistical methods, i.e., factorial experimentation and correlation analysis, can be used to increase bleach plant efficiency by providing a means toward a more thorough understanding of the bleaching process.

An example of simple correlation is given, without computation, and an indication made as to how correlation analysis can be applied to more complex systems. Preliminary steps in the variance analysis of a simple factorial experiment serve to show how this technique reveals significant interactions between variables. Confounded and fractionally replicated arrangements are described briefly in their relation to lightening the work load of many factor experiments.

It is concluded that proper application of statistical procedures should materially assist process operation.

An Industrial Lecture Program for Students of Chemical Engineering, Lyle C. Jenness

The reasons for introducing the program into the undergraduate curriculum for students of chemical engineering who major in pulp and paper technology are described. The lecture series has been in effect for the two previous academic years at the University of Maine and is being continued.

In each of three courses, lectures are given once a week by visiting industrialists from the pulp and paper or allied fields. The lecture courses are in pulp technology, paper technology, and pulp and paper mill equipment. The administration of these courses is described, and a typical program for each course is listed. The type of subject matter discussed is also described.

Comments are made on student reactions to the program, the publication of the lectures, and on the need for graduates who have received this training. Acknowledgment is expressed to the men who have conducted the lectures and to the companies represented by them.

Factors Influencing the Service Life of Brick Linings in Sulphite Digesters, Beaumont Thomas

In the operation of a sulphite digester, there are certain factors which tend to place the brick lining in tension and other factors which tend to place the lining in compression. If a tight seal is to exist between lining and shell at all times, the lining should be designed so that the sum total of compressive stresses exceeds the tensile stresses. On the other hand, compression should not become so great as to cause a breakdown of the brick or other materials.

Of the two factors which contribute to compression in the lining, one reaches a maximum over a period of time and then remains practically constant, while the other varies widely during the cooking cycle and from time to time. The "residual" stress which is dependent on the moisture swelling and elasticity of the materials may reach a maximum after approximately 1 year of service and may vary relatively little thereafter. However, the compressive stress which results from the difference in thermal expansion between shell and lining obviously varies during the cooking cycle.

It is therefore necessary in the design of a lining to first consider that the lining must be kept tight to the shell during the early period before the residual stress has had time to develop. Then, it is necessary to consider that the strength of the lining materials should not be overcome when the residual stress is finally developed and is added to the stress resulting from differences in thermal expansion.

Actual temperature measurements taken over a 2-year period show that excessive cooling of the shell caused by extreme external conditions or an accumulation of various influences resulting from careless operation, may disturb the balance which is normally set up. A study of the temperature gradients through the lining at various times during the cooking cycle and with varying external conditions emphasizes the need for consideration of the possible effects of cold drafts, varying installation temperatures, rapid steaming during start-ups, rapid cooling of the lining face, and other such factors which frequently are overlooked.

Sufficient safety can be incorporated in a lining design and with proper choice of materials to resist all but the most extreme conditions. With a reasonable amount of care in operation and with due consideration of a few precautions, a lining life in excess of 10 years is not difficult to attain.

Corrosion of Mild Steel and Mild Steel Welds in Sulphate Digesters, R. A. Huseby and M. A. Scheil

This paper consists of a report on a large-scale test program initiated to obtain more exact relative corrosion resistance of mild steels and mild steel welds in the sulphate process. Specifically the following points were to be studied:

1. Relative corrosion resistance of modern semikilled and fully killed steels.
2. Corrosion resistance as related to exact chemical analyses.
3. The effect of surface finish.
4. Comparative tests on several mild steel welds—manual and submerged arc.
5. Corrosion resistance of several low alloy high tensile steels.
6. Data on the galvanic effect obtained by coupling mild steel to several stainless steels.
7. The effect of various heat treatments.

Exposure was for slightly over 1 year in a tumbling digester on the West Coast. Specimens were large, measuring up to 36 inches long by 15 inches wide by $^3/_4$ inch thick and so installed as to be subjected to the same conditions throughout. Also specimens were installed so as to be subjected to the same wiping action the digester wall undergoes.

Results can be summarized as follows:

1. Corrosion rate of plate stock varied from 0.028 inch per year for semikilled A285 to 0.138 inch per year for the highest silicon content and the addition of up to nearly 1% of chromium, nickel, or manganese with smaller additions of copper and molybdenum had no effect.

The same general condition prevailed with the weld deposits although here the relationship was not entirely linear.

2. Surface preparation has some effect with best resistance shown by plate covered with the hot-rolled mill scale and poorest shown by a sandblasted surface.

3. Heat treatment above the critical range for the steel markedly lowers corrosion resistance.

4. The galvanic effect is not dangerously severe with Type 347 or Inconel. Type 430 straight chromium steel causes some accelerated corrosion of mild steel when electrically coupled in unfavorable area relationships.

The Effect of Silicates on Digester Corrosion, J. C. Hair and A. W. Duskin

The effect of silica-bearing cooking liquors on sulphate digester corrosion is presented. Since the installation of new digesters at the Crossett Paper Mills in 1945, the digester corrosion rate has been excessive.

On retiring two of five digesters from service in 1949, after less than 4 years of service, an attempt to prolong the life of the remaining vessels was begun by adding sodium silicate to one digester and an aluminum silica clay to the recovery furnaces.

Silica content of the cooking was increased to 600 p.p.m. SiO_2, over a period of 9 months. Corrosion rate of the digester shells was not affected nor did the high silica content liquor detrimentally affect evaporator operation. Indications were that evaporator tube life may have increased.

This mill scale study based on previous work of Benedicks and Von Essen concludes that silica-bearing cooking liquor produced by adding sodium silicate to the liquor will not inhibit digester corrosion nor will it aid the formation of a protective scale on digester shells.

Paperboard Drying: an Investigation by Means of an Experimental Drying Machine, Stanley F. Smith and B. W. Atwood

An experimental drying machine is described which subjects moist paperboard to a drying process closely matching that on the drier section of a making machine. The main variables of drying, 11 in all, are under close control, and the effect of varying each, or the effect of any proposed drier section layout, on drying rate or sheet properties, can be studied. Results are very reproducible and satisfactory agreement is shown with the drying rate of an existing paperboard machine operating under the same conditions. The following effects have been studied:

Drying rate is considerably increased by increasing the drier felt tension (which increases the contact pressure of felt on sheet

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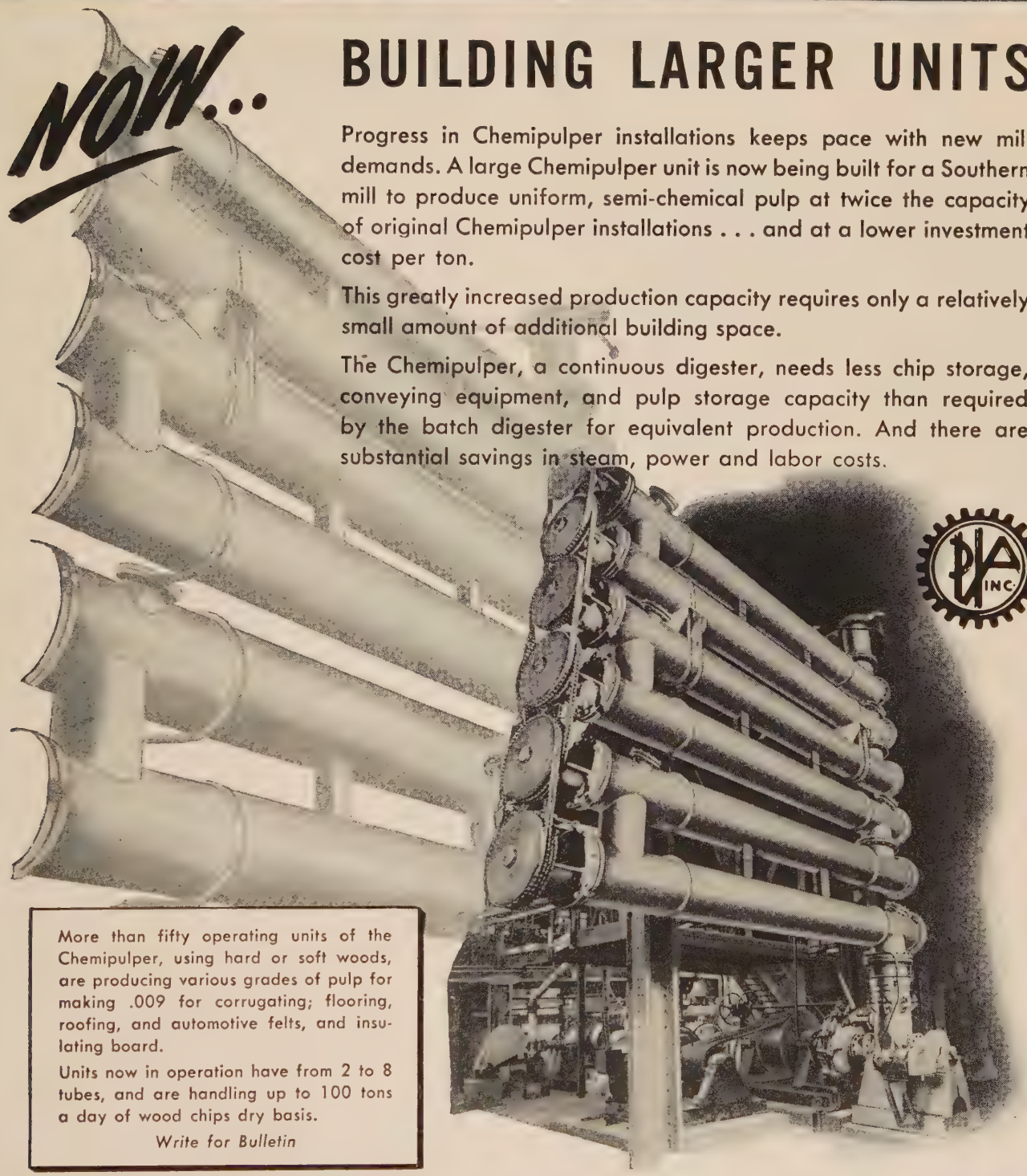
This greatly increased production capacity requires only a relatively small amount of additional building space.

The Chemipulper, a continuous digester, needs less chip storage, conveying equipment, and pulp storage capacity than required by the batch digester for equivalent production. And there are substantial savings in steam, power and labor costs.



More than fifty operating units of the Chemipulper, using hard or soft woods, are producing various grades of pulp for making .009 for corrugating; flooring, roofing, and automotive felts, and insulating board.

Units now in operation have from 2 to 8 tubes, and are handling up to 100 tons a day of wood chips dry basis.

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and sheet on cylinder), over-all increases of up to 50% being shown.

Conditions in experimental work were related to measurements of air conditions in making machine drier sections. A very large increase in dryness of air (from dry bulb 145°F., wet bulb 143½°F. to dry bulb 145°F., wet bulb 90°F.) increases the drying rate only moderately—12% for the initial drying rate and 36% for over-all drying rate. Doubling the air velocity in relation to the sheet had little or no effect in raising drying rates.

Widely spaced cylinders have slightly higher drying rates. The effect is not large.

Cylinder diameters of 2 feet 6 inches, 5 feet, and 10 feet were studied. Highest drying rate is with 2 feet 6 inches, lowest with 10 feet. The greater part of the difference is due to the lower pressure of felt on sheet and sheet on cylinder with the larger diameter drier, but a residual effect due to the greater efficiency of drying of the more rapidly repeated cycle with the smaller cylinders is found.

Five-foot diameter cylinders run at 120, 240, and 480 f.p.m. were studied. The drying rate increases to a moderate extent with the speed owing to the greater efficiency of the more rapidly repeated cycle over this range of speeds. The increased velocity of the sheet through the air has practically no effect.

Conventional felts, linen, and woven wire cloths were examined, also an impermeable felt. Impermeable felt gave much the lowest rate, linen and wire cloth somewhat higher rates than conventional felts.

The light these results throw on the mechanism of drying is discussed, also the possibilities of the machine as a research tool.

The Role of the Hemicelluloses in the Mechanism of Wet Strength, MANUEL N. FINEMAN

Beaten sulphite and rag pulps were treated with cold 17.5% alkali to remove the hemicellulose fraction. The extracted pulps were then washed and made into handsheets, and their strength properties compared with those of sheets made from the untreated pulps. The data obtained confirm earlier concepts that the hemicelluloses are responsible for interfiber bonding and, hence, are a major factor in the strength of paper.

The response of these papers to wet strength resin treatment was examined and the results show that, in the absence of hemicellulose, the wet strength resins were totally ineffective. From these data the mechanism of wet strength is shown to be the insolubilization and reinforcement of the hemicellulosic constituents by the wet strength additives.

The nature of the interaction of resins with hemicellulose is discussed and it is shown that any material which will interact with the hemicelluloses so as to reduce their degree of swelling in water, will be suitable for use as a wet strength additive.

Monomeric cellulose reactants will improve wet strength without altering dry strength. However, thermosetting materials will interact both physically and chemically with the hemicellulosic phase and consequently will not only reinforce the interfiber bonds and improve dry strength but will also make these bonds less water swellable, thus improving wet strength as well.

The mechanisms of tear strength and of softness in paper are also considered in terms of the role played by the hemicelluloses, and conditions which may promote improvements in these properties are suggested.

The Mechanism of the Improvement of the Wet Strength of Paper by Polyethylenimine, PAUL E. TROUT

Polymers of ethylenimine having degrees of polymerization in the neighborhood of 100 were prepared in laboratory quantities. The chemical behavior of the resins was typical of that of secondary amines, the most interesting aspect being the cross linking of the polymer molecules by the action of formaldehyde. Physically, the polymers behaved like polyvalent electrolytes, ionizing in aqueous solution.

The ionization of polyethylenimine was found to be an important factor in its retention by cellulose. Investigation of the retention mechanism showed it to involve a cation-exchange reaction. By this reaction, polyethylenimine cations replaced the hydrogen ions or metal ions of the carboxyl groups present in the cellulose.

In support of this theory, it was experimentally demonstrated that an increase in the polymer concentration displaced the equilibrium to the right, i.e., increased retention. Addition of hydrogen ions or of sodium hydroxide decreased polymer retention. Neutral salts, as expected, decreased polymer retention only slightly. The measured heat of polymer sorption was also compatible with a cation-exchange mechanism. The final link in the chain of evidence was the fact that the sodium content of the equilibrium sorption liquor increased as the polymer retention of the pulp increased.

The wet strength mechanism of polyethylenimine comprises the cross linking of the fibers by polymer bridges between the carboxyl groups of adjacent fibers—a simple and logical extension of the retention mechanism.

This was deduced from the experimental observations that cross linking of polyethylenimine-treated fibers by formaldehyde increased wet strength; that the wet strength imparted by polyethylenimine alone developed under conditions precluding polymer-to-polymer cross linking; and that increasing amounts of sodium were freed from sodium oxycellulose handsheets as the wet strength of the sheets increased.

Factors Influencing the Retention and Efficiency of Wet Strength Resins, C. S. MAXWELL, W. F. REYNOLDS, AND R. R. HOUSE

Three typical wet strength resins, (1) melamine formaldehyde acid colloid (cationic), (2) anionic urea formaldehyde resin, and (3) cationic urea formaldehyde resin are compared on a laboratory scale under a wide variety of circumstances. Factors that were found to affect the efficiency of one or more of these resins include: (1) concentration of anions and cations in the stock, (2) character of the pulps themselves, (3) degree of refining of the pulp, (4) time of contact between resin and fiber, (5) stock temperature, (6) degree of cure, and (7) cooking and bleaching residues.

A number of curves and tables, illustrating the effects of the variables studied, are given.

Phenol-Formaldehyde Resins for Wet Strength Paper—High Resin Contents by the Beater Addition Process, FRANCIS H. SNYDER, L. SPIWAK, AND A. E. MOYER

A new magnitude of wet strength and permanency in papers has been developed for applications involving rigorous use conditions. By the addition of 1 to 25% of phenolic-type beater addition resins, papers having wet versus dry strength in the range 35 to 130% are being commercially produced. In addition to good resistance to acids and alkalies, certain other physical properties have been improved such as increase in dry tensile and scuff. Such stocks do not suffer from embrittlement due to the resin, and when used in combination with elastomer latices exhibit considerable increase in fold endurance. The method of treating the beaten pulp with resin is simple, and papermaking operations are not complicated. The resin appears to react chemically with hydrated cellulose. Data are presented for the increase in wet strength upon the addition of varying amounts of resin with different fiber furnishes. Values for effect of resin treatment on dimensional stability of unbleached kraft stock are cited. A report on a typical filter paper prepared by this process indicates the excellent durability in contact with hydrated lime, as well as resistance of the stock to elongation under load and retention of wet tensile strength while maintaining filtrate clarity. A number of applications are suggested for papers of this type based upon their unique physical properties.

The Influence of Temperature During the Beating Process, O. K. RONNING AND C. E. LIBBY

Strong unbleached sulphite pulp was beaten in a Noble and Wood laboratory beater at various constant temperatures (5 to 80°C.). The beater was equipped with a surrounding jacket containing a cooling or heating medium for temperature control.

Experiments carried out at 4% consistency on pulp added to the beater in wet laps, showed a gradual increase in beating time to reach the same freeness (or drainage time) when the temperature was increased. The relationship between freeness and drainage time was found to be influenced by the beating temperature in such a way that the drainage time corresponding to a certain freeness was decreased as the temperature was increased. Initial greaseproofness occurred at a lower drainage time when the temperature was lowered. The best average strength properties of the handsheets resulted from moderately high beating temperatures.

When the same pulp was added to the beater in an air dry condition, the shortest beating time did not appear at the lowest, but at an intermediate beating temperature, around 30°C. The beating time necessary to reach the same drainage time was increased for all temperatures compared with similar runs starting with wet pulp. The trend in relationship between freeness and drainage time was the same. The appearance of the greaseproof point was greatly delayed. Burst and tensile strength values were considerably lower, while the tear and bulk values were higher.

Beater runs carried out at 2.5% consistency on wet pulp furnish showed that a longer specific beating time was found necessary at all temperatures in order to reach a certain drainage time, compared with beater runs at 4% consistency. The change in consistency did not to any great extent alter the trends of the strength properties. An attempt has been made to explain the reason for the difference in results obtained in the various investigations on beating temperature.

Description and Action of the Morden Slush-Maker Pulper, R. BURKE MORDEN

The Morden "Slush-Maker" for pulping, mixing, and prelimi-

A REMARKABLE RECORD ON A GREAT MACHINE

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Below is an excerpt from the trade press report on Mr. Crowder's talk at the recent Engineering Conference at Cincinnati where he described the amazing performance record of Macon Kraft Company's huge new machine—"The Buccaneer"—which is completely equipped with Ross Air Systems.

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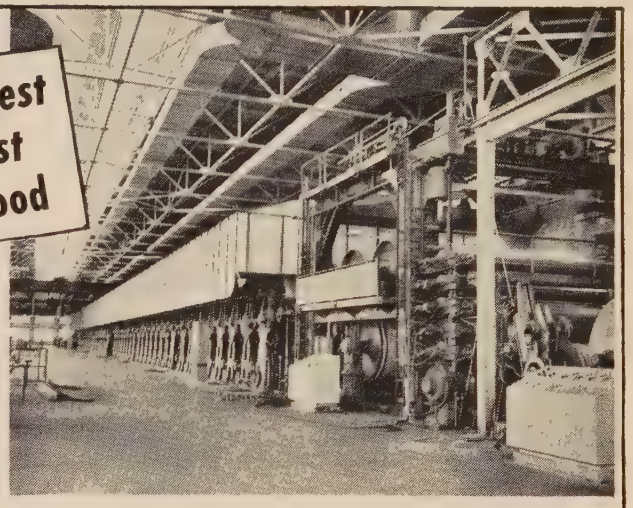

Macon Kraft Company's new "Buccaneer" machine showing huge ROSS Insulated Panel Hood, 352 feet long. Ducts above, fitted with special distribution heads, are directing air toward machine room roof.

...dryer section.

During a recent 24-hour period the Macon machine produced 838.99 tons of kraft. Mr. Crowder raised the eyebrows of other machine operators and had the engineers making some hasty calculations with pencils and slide-rules when he established that "only 1.24% of the total water to the wire was removed in the dryer section." The stock was at a consistency of .73%. The machine was running 1045 f.p.m. Moisture removal was computed as 97.4% of the total to the wire. It took 263,016 lbs. of steam per hour for drying and ventilating.

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nary beating was conceived by C. W. Morden, as a logical and desirable addition in the stock preparation field.

Some 15 years ago his conception of the "Stock-Maker" for continuous beating and refining more efficiently and effectively replaced the beating function of the beater. Now the "Slush-Maker" has been designed to replace the beater's functions of pulping, breaking, slushing, mixing, brushing-out, and treating various pulp furnishes either on a continuous or batch basis.

During the design and development of this unit over the last 5 years, many other pulping units have been introduced into the field. However, the "Slush-Maker" embodies principles that differ from these units. The theory underlying the "Slush-Maker's" process development being that such a unit must not only quickly and efficiently give the initial disintegration to the material, but that once this point was reached, the action of the unit should be readily controllable so that remaining flakes and bundles can be readily brushed out of the stock, color, and other additives mixed and brushed in, furnishes blended and, if desired, given a general preliminary treatment.

To accomplish this variety of actions it was determined that, just as in the beater, some controllable bar-to-bar action was essential. In the "Slush-Maker" there is not only a disintegrating or shredding disk but in addition there is an attritioning surface wherein bar settings, for a variety of treatments, can be adjusted or maintained as simply as in a beater or refiner.

To adequately study the action principles on a wide variety of materials, a pilot machine was built to handle 150 pounds of air-dried stock at 5% consistency.

Illustrations will point out how the unit is constructed to accomplish this complete disintegration of the stock as well as some of the test results on a variety of pulping operations. Larger units are being designed, based upon experience with this first unit, which will embody all of the basic features outlined herein and the operation of these units will naturally add to the data already accumulated.

This pilot model is set up in a laboratory in Portland where at any time trials can be run on any pulps that the industry cares to submit.

Pulping of Waste Paper and Pulp in the Dynopulper, G. A. Peterson

The principle called "dynomizing" which is a coined word is used to denote the singular and original treatment given to paper-making fibers and is used exclusively in various types of Dyno-machines.

Two or more Dynopellers are used in each Dynomachine. The Dynopeller consists of a cup disk, mounted on a horizontal shaft and inserted in the vertical ends of a vat. At the periphery of the disk on the concave side a 10-inch strip of sharp diamond hard particles are welded. When the Dynopeller rotates it acts in a similar manner to the impeller of a centrifugal pump, drawing the stock to its center, the centrifugal force set up causes the stock to flow across the sharp roughened area under a slight hydraulic pressure which tears and pulls the fibers apart, this work being done without cutting or shortening the fibers.

All types of waste papers and pulp are very quickly reduced to slush form in the Dynomachine, the treatment continued in the machine until such time as all small particles of paper and fiber bundles are separated into individual fibers.

The Sandy Hill Peppy Peeler, Douglas Philbrook

Changing economic conditions, shifting of locations of pulpwood areas, desirability of utilizing supplies of pulpwood otherwise a total waste, and economics of operation of pulp mills have made increasingly necessary a portable pulpwood peeler. One which is practicable, economical, and adaptable, is described. This peeler has the following attributes in relation to the needs of the situation. With its power plant (gasoline, diesel, or electric) it is truly light enough to be portable. In the words of a user it is: "mechanically dependable for years of operation." It will bark all softwoods, some hardwoods, wet wood, dry wood, newly cut wood, pest and storm killed wood, and frozen wood. It has an economical figure of fiber loss under all conditions. Figures as to production in cords per man-hour, power consumption, after fiber loss are given as determined both in commercial and research center operations.

The Sandy Hill "Peppy Peeler" provides, after years of trial of a variety of barkers, a practicable portable wood barker. This barker satisfies the basic requirements of being usable anywhere where barking is required from the point of cutting the wood to the wood yard of the pulp mill. Bark can be left in the woods for refertilizing the ground, and cost of shipping it on the logs eliminating the tremendous expense of disposing of the bark from the mill yard.

Toward a Referee Viscosity Method for Cellulose, A. F. Martin

A referee method for cellulose viscosity should combine the following features: reproducibility, rapidity, simplicity, correlation with use properties, correlation with chain length, and applicability to all types of cellulose. The method should also protect the cellulose from degradation during measurement and should encompass the best features of modern techniques of viscometry, including correction for velocity gradient. No existing viscosity method appears to have a suitable combination of all of the features mentioned above.

A new possibility for fulfilling the above requirements more completely has been suggested by a statistical study of the errors inherent in using the author's equation relating observed to intrinsic viscosities. It is proposed to use intrinsic viscosity as the reported viscosity value for all samples. Viscosities would be run at a concentration such that for all samples the product of intrinsic viscosity and concentration would always be the same value. Under these conditions, all viscosities would be measured at a standard velocity gradient.

Although the expressions given in this paper have been derived on the basis of the Martin equation, the same principles could be applied if other viscosity-concentration relationships were used.

Moisture Determination in Paper by Oven Drying, G. Broughton and A. K. Hobbs

Methods of moisture determination on small samples of paper are reviewed with particular reference to oven drying.

Sources of error are discussed critically.

Results on cage and weighing bottle methods in free convection air ovens are presented for a number of papers. Oven temperature was maintained at 105 °C. It is believed that the results are indicative of the precision that can be expected in normal, routine work.

Effect of Melamine Resin on Chemical Tests of Paper, W. K. Wilson, J. L. Harvey, and A. J. Padgett

A study of the effect of melamine resin (MR) in paper on various chemical tests applied to paper has been made. Included are the determinations of alpha, beta, and gamma-cellulose; copper number; pH; rosin; cuprammonium fluidity; and the heat stability test.

It has been found that MR generally increases the alpha-cellulose fraction, through resin bonding; the increase ranges from 0 to 3% alpha-cellulose, depending on the original alpha-cellulose content of the fibers and on the amount of the resin added. The change occurs at the expense of the beta-fraction, the gamma portion being unaffected. Seventy-two to 85% of the MR remains in the alpha-cellulose portion. Owing to this distribution of the resin in approximately the ratio of the alpha and the beta plus gamma-fractions, the correction for consumption of dichromate by the resin in the volumetric determination usually has a negligible effect.

The MR causes a slight decrease (0.2 to 0.4) in copper number; papers having a degree of polymerization without MR of 1000 or more become partially insoluble in cuprammonium solvent, so that viscosity measurements are rendered meaningless; the analysis for rosin is not affected. It is shown that during hot water extraction MR releases alkaline decomposition products; consequently the hot-extraction pH of a paper may be higher, lower, or equal to the cold pH, depending on the relative amounts of alum and MR present.

The state of cure of the resin does not appear to influence the alpha-cellulose value and copper number in the same manner as it does the fold endurance during the heat stability test. As measured by the changes occurring in alpha-cellulose value and copper number, MR exhibits a tendency to stabilize papers. Further work is necessary before the heat stability test can be used as a satisfactory measure of the relative permanence of papers containing synthetic resins.

Characterization of Petroleum Waxes by Solvent Fractionation Methods, F. H. MacLaren

Petroleum waxes, used in large quantities in the manufacture of protective wrappings for foods and confections, have been the subject of many published papers dealing with physical properties, crystal form, composition, and methods of manufacture. Study of these hydrocarbon mixtures is quite difficult because of highly complex and closely related chemical composition which prevents use of simple methods for characterization and classification. Application of specially developed laboratory solvent fractionation procedures has been found to be of considerable aid in showing melting point distribution of the components of paraffin waxes, motor oil waxes, microcrystalline waxes, petrolatums, and tank bottom waxes. These solvent fractionation methods for characterization of commercial waxes show trends which can be related to known service performance requirements in the wax coating and laminating fields. Data obtained by one of the solvent fractionation techniques compare closely with those obtained by lengthy vacuum fractional distillation. While these solvent methods do not give answers in terms of ultimate chemical analysis, they do provide reliable data for quickly appraising

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waxes in respect to melting point distribution which is shown to have an appreciable effect on the performance of a wax in service.

Determination of Iron in Wood and Wood Pulp, R. M. Kingsbury

Work at the U. S. Forest Products Laboratory has shown a need for a more rapid and reliable method for determining iron in wood and wood pulps than the present TAPPI method for determining acid-soluble iron in paper. Certain features of procedures described in the literature for the wet ashing of organic material and the determining of traces of iron with *o*-phenanthroline were combined to provide a rapid and precise procedure for use on cellulosic materials.

The procedure includes: (1) wet digestion of the material with sulphuric, nitric, and perchloric acids, (2) reduction of iron to the ferrous form with hydroxylamine hydrochloride, and (3) spectrophotometric determination of iron as the *o*-phenanthroline complex. The iron content in parts per million of sample is obtained directly from a calibration curve prepared from the transmittancy of standard iron solutions digested and treated exactly the same as samples of the materials in analyses.

Danger of fire or explosion from the use of perchloric acid is avoided by a preliminary digestion with nitric and sulphuric acids. Excessive fumes are conducted to the drain by means of a glass aspirator pump and a glass adapter tube.

Data are presented which show that the sensitivity and reproducibility of the method are in the range of 1 part of iron per million parts of sample.

Ten references are cited.

Relation of Red Slimes to General Paper Mill Slime Control, J. R. Sanborn

This report is primarily concerned with the troublesome pink or red slimes which, in practice, are notorious for their persistent and elusive properties. These findings are part of a continuous investigation to determine mill conditions which encourage "nuisance" growths in pulp and paper systems and to develop suitable methods of control.

Twenty different groups of red slime-producing microorganisms have been studied from 100 characteristic outbreaks in 65 mills representing 19 States and 4 Canadian Provinces. Of the various causal organisms involved in the foregoing instances, 60 were yeastlike fungi, e.g., *Rhodotorulas pp.*, *Monili. spp.*, *Monascus spp.*, etc. Mold growths, such as *Cephalothecium spp.*, *Fusarium spp.*, and *Asochyta spp.*, accounted for approximately one half of the remainder while spore-forming and nonspore-forming bacteria, e.g., members of the genera *Bacillus*, *Serrati.*, and *Micrococcus* were principal organisms in the other instances.

The red pigment-producing groups are diversified, known to mills for their: (1) adaptability to specific locations in mill systems, e.g., screens, flow boxes, savealls, machine trays, sides of suction boxes, etc.; (2) fugitive and unpredictable behavior as to appearance of growth and color; and (3) resistance to ordinary control measures. While these growths are influenced by mill conditions, e.g., temperatures, H-ion concentration, air supply, available food and suitable breeding places, in practice the immediate reasons for their sudden and unexpected appearances are not always clearly evident. Certain slimes appear to develop characteristic color most readily when specific associates grow together.

Unquestionably, the most direct procedure for determining immediate and contributory causes of troublesome growths is to carry out on-the-spot engineering and microbiological surveys of mill conditions. Successful control of red color-producing growths can be accomplished by consistent and timely use of chemical treatments which inactivate potential slimes and kill the causal microorganisms, e.g., through contact oxidizing agents, combined phenolic fractions, and cationic killing compounds.

Infestations of red slimes are being controlled, therefore, by preventive programs based on early recognition of potential trouble, identification of causal organisms, and general and localized applications of specific chemical treatments selected for individual mill conditions.

A New Method of Detecting Slime in Pulp and Paper, Stanley J. Buckman and Virginia Henington

The practice of classification of the cause of spots in pulp and paper and paper breaks based on visual inspection yields some useful information when the classification is made by an experienced observer. It also has been possible to determine the cause of certain types of spots by chemical tests, microscopic examination, and examination under ultraviolet light. However, a reasonably specific test for slime has not been available to supplement gross visual inspection. Culturing "wet tails" by pouring culture media around the "tails" in a Petri dish or by pressing the "tails" on the surface of culture media and observing the growth pattern obtained has provided helpful indications although the results frequently are difficult to interpret. Moreover, the method is time consuming and is not applicable to "dry tails" or the examination of spots on paper which has passed through driers with the resultant killing of most of the microorganisms present. Microscopic examinations also have been employed and some information has been obtained in this manner when examinations were made by experienced microscopists. However, like the culture method, the results of the microscopic examinations, in general, have left much to be desired and neither method has filled the need for a comparatively simple, reasonably rapid and reliable test which can be employed as a supplement to conventional visual inspection. In an endeavor to meet this need, a study was made of a number of chemical tests which might be employed to detect accumulations of microorganisms in pulp and paper, including deposits from pulp and paper machine systems. A test for protein, which is universally present in microorganisms and not present in detectable amounts in uncoated paper, such as newsprint and kraft, seemed to be a preferred approach. A test reagent consisting of a solution of ninhydrin (triketohydrindene hydrate) buffered with sodium citrate was adapted for use on pulp and paper. A small amount of the indicator is placed on the center of the suspected slime spot or portion of the "tail" where the break is believed to have originated and the same amount of indicator on a control area on the same piece preferably at least 2 inches from the suspected slime spot. The indicator is allowed to soak into the spot on the pulp or paper for 10 minutes and the piece then is transferred to an oven where it is heated at 90 to 105°C. for 3 to 10 minutes with frequent observations during the heating period. Proper control of heating is important, and the piece is removed at the first evidence of the development of color in the control spot. The development of a color within the range from red through violet to blue in and around the suspected slime spot is a positive result and indicates the presence of slime if the color is darker than that obtained on the control spot. Extensive laboratory tests with known samples of slime have provided evidence in support of the conclusion that very small amounts of slime can be detected on pulp and paper. The slime was detected even after drying in an oven at 105°C. although it usually was easier to detect fresh undried spots. Cooperative work with a number of pulp and paper mills has confirmed that the indicator is helpful in detecting the presence of slime in pulp sheets, "tails" from paper machine breaks, breaks from pressrooms, and deposits from pulp and paper machine systems. Information about the indicator and a description of the method of use is presented so that it will be generally available for others to employ in further exploring the complete range of usefulness of the indicator as well as its limitations.

Pink Slime in Paper Mills—Identification and Control of Certain Causative Organisms, John W. Appling, N. Jean Ridenour, and Stanley J. Buckman

Pink slime is of unusual importance in some paper mills because it is a difficult slime to eliminate and also because it produces undesirable pink spots in white paper. The authors have studied a group of seven pink slimes which originated in six fourdrinier paper machine systems and in one top white liner vat system of a cylinder machine. The objective of this study was twofold: first, to isolate and identify the pigment-producing organisms in pink slimes; and second, to learn how to control these more efficiently. Thus far, the authors have isolated the pigment-producing species of organisms from three pink slimes which came from three fourdrinier systems. Three species of bacteria were found repeatedly in these slimes and they have been tentatively identified as: *Alcaligenes viscosus*, *Bacillus subtilis*, and *Flavobacterium marinum*. The last-named species belongs to a genus which is characterized, in part, by yellow colonies. A surprising discovery, however, was that all isolates resembling either *Alcaligenes viscosus* or *Bacillus subtilis* readily produced pink pigment when grown on a potato infusion agar at a pH of 6.1. In order to study the control of these pigment-producing bacteria, percentage kills were determined in a pulp substrate. The results of these tests and other work suggest that neither individual cells nor small aggregates of these organisms offer any unusual resistance to commonly employed slime control agents. Thus, the effective control of such organisms must be directed at thick films and relatively large masses of these organisms. Thorough cleaning of the mill system by washing and scraping accessible surfaces followed by spraying these surfaces with BSM-11 or Butrol has been found effective. When the infection is present in locations which are not readily accessible, the circulation of a hot toxicant-detergent solution throughout the system for several hours has been found preferable, particularly when followed by the spraying of accessible surfaces.

Microbiology of Certain Paper Food Containers, Ernest Reed

A presentation of the summation of the data of the microbiological studies of certain paper food containers and that of paper materials out of which such food containers are fabricated.

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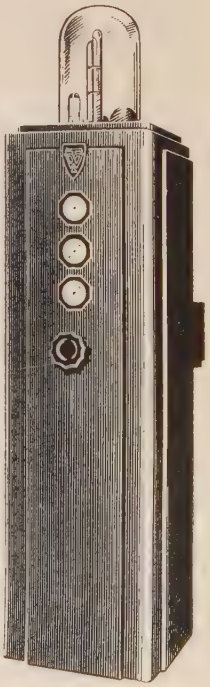

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Commercial Sulphite Production Experience with Ammonia Base, L. A. La Fond and W. F. Holzer

Ammonia-base sulphite acid has successfully replaced dolomite base acid for the cooking of western woods at the Lebanon, Ore., mill of Crown Zellerbach Corp. The conversion involved installation of equipment to convert anhydrous ammonia to a solution at 17% concentration, a means to meter ammonia into the Barker tower, and elimination of all copper alloys from the system. With instrumentation now installed the acid plant operation is very nearly automatic. One digester lining was worn out and was replaced with a type recommended for soluble-base acid. The second lining, almost new, is a conventional lining. It is performing satisfactorily, but is expected to give short life.

The combined SO_2 has been lowered from 1.30 to 0.85% with no harm to pulp quality other than color. Cooking is much more rapid so that the mill has been able to reduce digester temperature by 20°F. at the same cooking rate, or 10°F. with an increase of 15% pulp production. Screenings have been reduced by more than half due to better penetration of the base, and the screening operation speeded up by 25%. The pulp requires a little less beating, but otherwise behaves the same in paper manufacture. The pulp bleaches normally, and uses the same chlorine as dolomite pulp on basis of bleachability.

Pulp and paper quality have improved except for color. Bursting strength, tensile, and fold have increased while tear remained the same. Sizing of paper has improved.

Advantages have been: increased pulp capacity, better pulp yields with decreased screenings, better pulp quality, more uniform and generally easier operation, and savings in operating chemicals and maintenance. Extra cost of ammonia has been offset by savings, and a vigorous slime growth controlled by slimicide chemicals.

The advantages of ammonia base are attributed primarily to its rapid penetration of wood and to its solubility. No evidence is available as to any difference in its reaction with lignin.

Chemical Reaction Equilibria in Calcium and Magnesium-Base Sulphite Recovery Systems, Roy P. Whitney, Richard M. Elias, and Malcolm N. May

Many sulphite pulp mills are considering possible systems of utilizing or disposing of spent sulphite liquor involving evaporation and burning. From the standpoint of recovery and reuse of inorganic chemicals in pulping, it is desirable that information be at hand regarding the chemical compounds which are formed in the recovery furnace, and regarding the effect of combustion conditions upon the extent to which each may be present. This paper presents the results of calculations of chemical reaction equilibria for many of the important reactions which may be involved in the combustion of calcium-base and magnesium-base spent sulphite liquor. The calculations have been based upon thermodynamic data for the several compounds of interest, compiled from the literation. They indicate the conditions under which the oxide, sulphide, or sulphate of calcium or magnesium might be expected to predominate, and suggest a possible explanation for the observed differences in composition of the ash from calcium-base and magnesium-base liquor combustion.

Spent Sulphite Liquor Studies—I. Program of the Sulphite Pulp Manufacturers' Research League, Inc., Averill J. Wiley

In 1939, 14 pulp mills (12 companies) using the calcium-base sulphite process in Wisconsin and Michigan organized the Sulphite Pulp Manufacturers' Research League for purpose of developing answers to the stream pollution problem. Much credit for success of the program is attributable to the time and effort devoted by the league's technical committee to careful delineation of research policy. This committee, with membership drawn from the technical directors of the pulp mills, averages more than 1000 man-hours of service annually in the league's interest.

Active, spent sulphite liquor research and development work of the league is carried forward through three channels; by its own research staff of 14, by working closely with numerous cooperating individuals and concerns, and through substantial research grants to universities and other technical centers.

Initially, all available ideas and processes were carefully abstracted and reviewed. Thorough laboratory evaluation followed wherever possible on likely ideas and in the first 11 years some 50 processes have received more or less detailed and serious consideration. A few have passed through laboratory and pilot stages into semicommercial and full commercial trial.

Research activities include development of: (1) processes utilizing the unmodified spent liquor or crude concentrates; (2) processes based on use of the lignin compounds and organic derivatives of lignin; (3) processes based on use of the wood sugars and their conversion products; and (4) recovery of pulping process values and other minor fractions.

Evaluated processes with most promise for commercial development to date include evaporation and burning of the liquor and production of torula yeast. Technical development of evaporation processes is well advanced and burning is also technically feasible. However, the over-all economics of burning the liquor are marginal at best. From the technical standpoint the yeast process is also well developed but the operations are high cost and must be balanced by sale of the yeast. Further expansion of yeast production facilities depends upon market development. A comprehensive program of university nutrition research is supported by the league to that end.

Uses of the liquor as a dust laying agent and as a possible medium for soil base stabilization on unsurfaced and surfaced roads are being further developed.

Determination of Total Non-aqueous Constituents in Pulp Mill Liquors, J. H. Phillips

The need for more reliable laboratory data for use in establishing accurate material and heat balances in the several pulping processes in the paper industry is emphasized. The problem of obtaining a reliable value for the "solids" content of residual liquors is discussed and a definition for "total nonaqueous constituents" is given. The suggestion is made that such a term be used in place of "total solids" in order to include gases and volatile liquids with the combustible portion of the liquor. This new definition and concept presents the problem from a different point of view and stresses the importance of developing a method for determining water completely independent of all other constituents in a liquor sample.

A review of the literature on methods of "moisture determination" and methods of "total solids determination" in other industries as well as the pulp and paper industry is included and a discussion of the pros and cons of methods currently used in pulp mills is given.

A method for the determination of total water in residual liquors is described. This method is a modification and adaptation of the well-known Karl Fischer titration. This method enables the user to obtain a more true value for the water content of a liquor independent of the composition or amount of the "total nonaqueous constituents" present.

This method is proposed with the acknowledgment that because of insufficient time exhaustive laboratory testing has not been completed and there are quite likely instances where slight variations of procedure will be necessary. However, it is presented along with the problem confronting the industry for the benefit of those who wish to try it. The data given indicate excellent sensitivity and reproducibility, but since there is no existing method by which completely satisfactory data can be obtained, no direct evaluation of accuracy can be made. However, comparison of results obtained do show slightly lower percentages of water by the titration method than those obtained on identical samples using an "oven-dried solids" method but they are of the same order of magnitude. The slightly higher value obtained for water by oven-dried methods can be attributed to the release of volatile liquids and gases from the liquor.

The Sulfox Process for Recovery of Chemicals from Acid and Neutral Sulphite Waste Liquors, R. S. Aries and Arthur Pollak

This new process provides for burning the waste liquor and recovering the inorganic chemicals. A soda base is used instead of the usual lime or dolomite base. After evaporating and burning the sodium sulphide in the ash is oxidized directly to sodium sulphite. Only standard equipment is used.

Air Prevention and Elimination in Stock to the Vats, G. C. Ehemann

This is a presentation of a series of slides illustrating the techniques and some of the results of studies currently in progress at Ohio Boxboard to determine how much air there is in stock at various points and how this air affects formation of paperboard on a cylinder machine.

The Preservation of Baled Straw in Ricks, C. W. White

A 3-year study of chemical preservation of straw has shown that borax, or cheaper forms of borate ores (Borascu) can give excellent results as well as practical results. One ton of Borascu applied over at least the two top tiers are effective on straw ricks exposed to weather. Straw may be preserved with less deterioration and consequently greater yield giving more consistent quality paper. Firm bales of straw with a minimum deterioration make easier and faster handling.

Dissolving Pulp from Bamboo, M. H. Joglekar and C. P. Donofrio

The findings in this investigation demonstrate that a highly satisfactory alpha pulp which may be utilized for dissolving purposes can be manufactured from bamboo through a series of chemical treatments consisting of acid prehydrolysis, sulphate digestion, and multistage bleaching.

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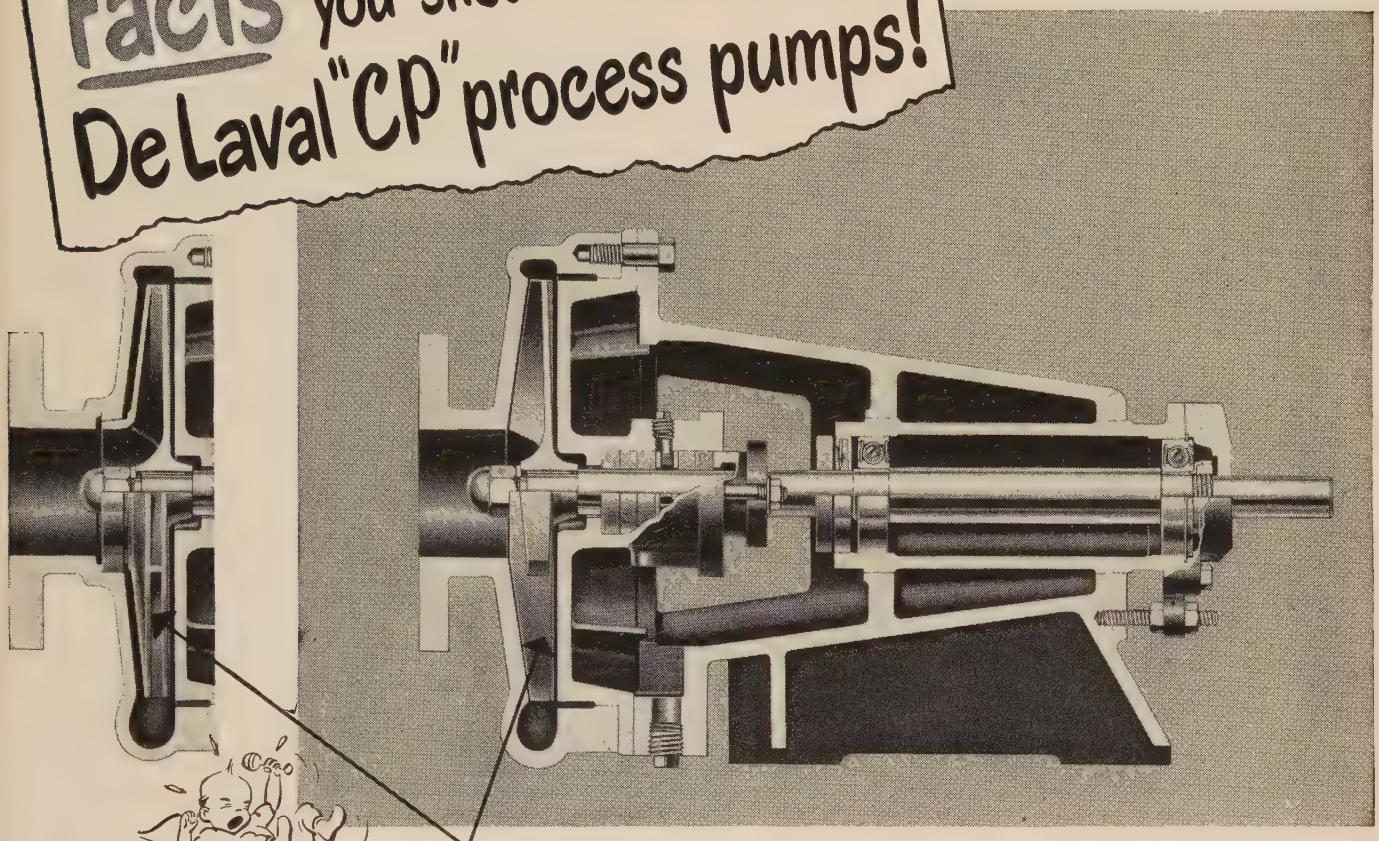

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By virtue of its chemical composition, i.e., high fractions of pentosans and silica, bamboo posed many difficulties in pulp purification when the conventional pulping procedures were employed as initial steps in alpha pulp preparation. Alkaline pulps (soda and sulphate) exhibited high residuals of the above-mentioned constituents which resisted removal in many of the wide array of methods established for pulp purification. The matter of pentosans suggested a strong similarity between the alkaline bamboo pulps and the alkaline pulps produced from our more common hardwoods.

Although low in residual pentosans, the bamboo sulphite pulps (prepared under carefully selected conditions) were found unsuitable for subsequent purification because of their highly degraded nature, high silica content, and inferior bleaching characteristics.

Acid prehydrolysis of bamboo was found to be highly effective in facilitating the removal of pentosans and silica in the subsequent sulphate digestion stage. Pulps produced in this manner were bleached to high brightness levels with ease and with low total consumption of chlorine (less than 4%) in two or three stages. Because of the high degree of purity secured in these pulps the conventional alpha treatment was unwarranted.

The suitability of sulphuric acid as the hydrolyzate and its reuse in the prehydrolysis of bamboo are discussed.

Excellent acetate syrups of low turbidity and clear films were prepared from the bleached, prehydrolyzed bamboo pulps.

Mechano-Chemical Process—Rate of Delignification, S. I. Aronovsky and G. H. Nelson

Pulping rate studies were made on wheat straw with soda, kraft, and neutral sulphite pulping chemicals at 73, 73, and 93° C., in a small open vessel fitted with a high-speed stirrer. The most rapid pulping rate occurred in the first 5 minutes. Delignification continued after this period but at a greatly retarded rate. About 55% of the lignin, 30% of the pentosans, and 85% of the ash, based on the amounts of these constituents present in the original straw, were removed in the first 5 minutes; at the end of 1 hour, the amounts removed were 70, 35, and 90%, respectively. At the same concentration, caustic soda and the kraft chemicals gave practically the same degree of delignification of straw; sodium sulphite was too mild a cooking agent to produce satisfactory pulp at the low temperatures used. Both the higher cooking temperatures and the higher concentrations of cooking chemical increased the rate of pulping, the change in concentration of chemical having the greater effect. Mechano-chemical pulping of commercial straw in a 3-foot Hydrapulper gave results in good agreement with those obtained with the small laboratory vessel. It is believed that the speed and efficiency of delignification in mechano-chemical pulping are due largely to the increase, by mechanical action, in the diffusion velocities of the active chemicals and reaction products into and out of the fibrous plant material.

Boxboard from Wheat Straw to Replace Wood Veneer in Wire-Bound Shipping Containers, E. C. Lathrop, T. R. Naffziger, and E. R. Stivers

Wire-bound shipping containers annually use about 1.5 billion square feet of wood veneer in thicknesses of $^1/_8$ to $^1/_4$ inch. The grades of wood veneer used for this purpose are meeting with increasing demands for other purposes at higher price levels. In order to stabilize this industry, the development of a container boxboard from wheat straw was undertaken. Cooperative research between the Northern Regional Research and Package Research Laboratories has resulted in a satisfactory solution of the problem. A wheat straw boxboard has been developed which shows performance in standard wire-bound shipping containers equal to wood veneer in respective thicknesses. The important steps in this development are discussed. Specifications for the shipping containers using the straw boxboard and of the board itself are presented. The process for manufacturing the board is described in some detail. Estimates for the capital cost of a plant to produce 123.5 tons of board per day are presented, together with approximate production costs. The estimated cost of production is $54.40 per ton. In competition with wood veneer at $110 per M board feet f.o.b. southern mills, straw boxboard can be manufactured at a price attractive to the box maker.

Agricultural Residue Pulps—Crotalaria Pulps, A. J. Ernst, H. M. Sutcliffe, and S. I. Aronovsky

Crotalaria is one of the more important leguminous crops grown on the sandy soils of southeastern United States for erosion control. The two most common varieties, *Crotalaria mucronata* and *Crotalaria spectabilis*, produce high yields of seed and up to 10 tons of green or 2 tons of dry forage per acre.

A number of pulping trials were made on these stalks, using the neutral sulphite and kraft processes. Crotalaria required more cooking chemicals and generally longer cooking periods than are necessary to pulp wheat straw. Lower yields of pulp were obtained from Crotalaria than from wheat straw but the Crotalaria pulps were stronger, particularly in tear resistance and folding endurance. In general, the kraft process produced stronger pulp than the neutral sulphite process but the kraft pulp yields were lower.

These preliminary experiments indicate that, from a technological standpoint, Crotalaria has good possibilities as a raw material for pulp and paper manufacture. Economic considerations, however, will undoubtedly be the controlling factors in the possible utilization of Crotalaria for pulp and paper production.

Hydrogen Peroxide Bleaching of Chemical and Mechanical Pulps—New Developments and Process Applications, R. L. McEwen, F. R. Sheldon, and D. H. Nelson

Disclosure of new developments in the hydrogen peroxide bleaching of chemical and mechanical pulps is made with particular reference to the former. Improved process applications permitting greater bleaching efficiency are presented.

The new high density (20 to 50%) peroxide methods include the continuous moderate temperature system for pulp crumbs and the semicontinuous cold steep bleaching process for crumbs, continuous webs, and cut sheets.

The mixed peroxide (H_2O_2 and Na_2O_2) chemical system for bleaching is discussed and data are presented which establish its high commercial efficiency.

Commercial and laboratory results on various peroxide processes are presented. Data are given on: (1) sulphite pulp bleaching in a single stage to 75 to 85 brightness and as one stage in a multistage system to reach the 85 to 90 brightness range, (2) kraft pulp alkaline peroxide extraction, and (3) kraft pulp bleaching and superbleaching in the final stage to the 80 to 90 brightness level.

At high brightness levels, minimum cellulose degradation resulting from selected peroxide bleaching methods is contrasted with excessive fiber damage often obtained with conventional chlorine methods.

Data are also presented on the peroxide bleaching of semichemicals, chemigroundwoods, and groundwoods of various wood species. The bleaching of agricultural residues and flax pulp are also discussed.

Investigations in the mill and laboratory have revealed bleaching techniques which results in interesting pulp properties. These techniques have led to the development of several new commercial processes which may be applied economically for the peroxide bleaching of most all pulp types.

Peroxide Bleaching of Groundwood and Sulphite Pulps, Richard A. Premo

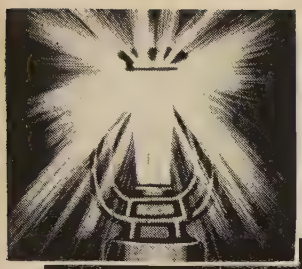
Modernization of the Gould Paper Co. mill and the conversion of this mill from the manufacture of newsprint and similar low brightness papers, to the production of higher grades of papers, required facilities for bleaching both groundwood and sulphite pulp. Since peroxide bleaching was known to be applicable to both pulps, it was possible to install one bleachery in which both groundwood and sulphite pulp could be bleached to the desired brightness, either singly or in mixtures.

Installation of a modern peroxide bleachery was completed in March, 1950. The bleachery is designed to operate at medium consistency (12 to 15% moisture-free basis) and has a capacity for bleaching 100 tons of groundwood or 130 tons of groundwood-sulphite pulp mixtures, or 130 tons of sulphite pulp per day.

Automatic equipment for the continuous preparation of the peroxide bleaching solution is novel in this mill. In this system the bleaching solution is prepared at the required rate in a four compartment stainless steel mixing tank. Metered quantities of water, Epsom salt, sodium silicate, sodium peroxide, and sulphuric acid are added in the several compartments in the given sequence. The finished bleaching solution flows to a storage tank from which a proportioning pump delivers it to the bleaching process.

Groundwood and sulphite pulp enter the process through separate consistency regulators and pulp meters, and drop into a seal box. From the seal box the mixed stock is pumped to a thickener which increases the consistency from 1.5 to 12–15% moisture-free consistency. The pulp mat is removed from the thickener cylinder by a high-speed take-off roll, shredded and conveyed, first to a single-shaft mixer where steam is introduced, and then to a double-shaft mixer where the peroxide bleaching solution is mixed with the pulp. From the double-shaft mixer the stock drops into a retention tower where it is held for the proper bleaching period and then dropped into an agitated chest for neutralization of the residual peroxide and alkali with sulphur dioxide. The bleached and neutralized pulp is then delivered to the bleached stock storage chest.

Various ratios of groundwood and sulphite pulp have been bleached in the process. Initial brightness of 62.5 Photovolt has been increased to 70.5 using 1.6% sodium peroxide. Increases of 10 to 11 points have been obtained with 2.0% sodium



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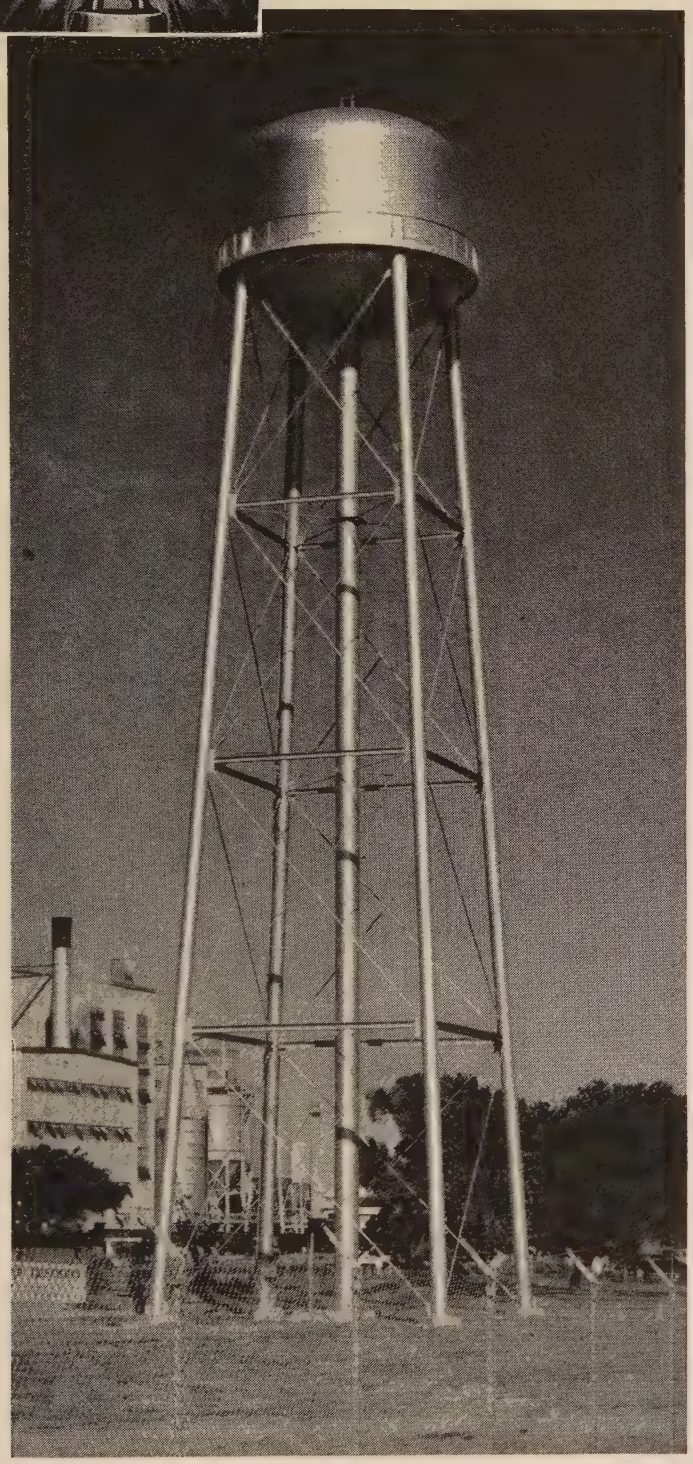

Throughout the years of its operation, the new pulp mill and paper plant of Fibreboard Products, Inc., at East Antioch, California, is certain to have water available for fire protection. Why? Because the primary supply for the plant's automatic sprinkler system is stored in the 100,000-gal. Horton elevated tank shown at the left. The supply is assured because the water in the tank is held for fire protection purposes only. Since the water is stored *above* the plant, it flows by unfailing gravity pressure.

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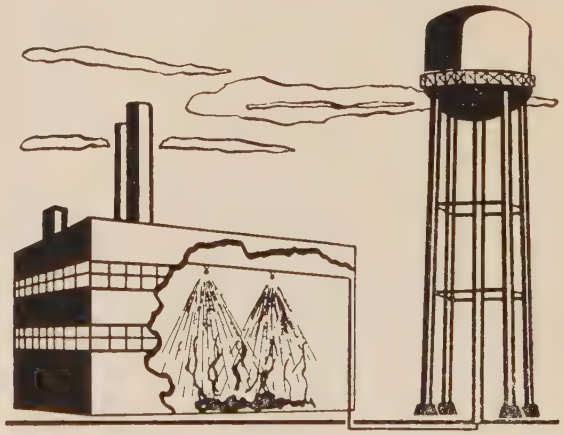

Diagrammatic illustration of an automatic sprinkler system supplied by an elevated water tank. The instant a fire starts, water—under gravity pressure—sprays from the first sprinkler head that opens. The fire is usually confined to a small area because the flames are quenched before they have a chance to gain headway.

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peroxide. For special furnishes, 100% sulphite pulp has been bleached from 55 to 57 to a brightness of 75 with 2% sodium peroxide.

The materials of construction for this process are not unusual to the paper industry and include stainless steel, tile, transite, steel, and rubber-covered steel.

Installation of this peroxide bleachery has enabled the Gould Paper Co. to produce higher grade papers. The bleachery has been giving good performance since the start of operations about a year ago.

Color Removal of Process Waters, J. H. Davidson

Highly colored waters, as noted in TAPPI's monograph on "Industrial Water for Pulp, Paper and Paperboard Manufacture," are unsuitable for use as process water in the manufacture of bleached pulp and paper. In order to furnish a suitable water for its 200-ton-per-day bleach plant, the Minnesota and Ontario Paper Co. installed in its mill at International Falls, Minn., a 15,000,000-g.p.d. filtration plant to remove the color from its Rainy River water supply which has a color ranging from 40 to 80 p.p.m.

This plant consists of two horizontal, concrete Permutit precipitators, each of which is 33 feet 6 inches wide by 112 feet long by 15 feet, 4 inches deep, and five concrete, gravity-type filters, each filter being 24 feet wide by 30 feet long by 13 feet deep, and a new filtration building to house the equipment. The raw water is chlorinated and then mixed with the treating chemicals in a baffled, mixing flume and introduced into the tops of the inner compartments of the precipitators through distributor flumes. As the water and chemicals pass downwardly through the inner compartments, agitators serve to effect an intimate mixing with the sludge and the development of a good floc.

At the bottom of the precipitators, the flow of water is reversed and it is filtered upwardly through a blanket of previously formed sludge, the height of which is kept between specified limits by blowing off sludge from the sludge concentrators at the same rate as new sludge is being formed. Since the sludge from highly colored waters is usually rather light and the temperature of the raw water falls as low as 34°F. during the winter, provision was made to feed as filter aids either activated silica or clay.

While both gave good flocs, the clay was found to give better results as the filter runs were about three times as long as when activated silica was used. The type of clay which was found to give the best results was the Proper Chemical Co.'s P-3 grade. Clay is fed only when necessary and there are periods when no filter aid is required. The dosages of alum and lime used vary somewhat but are roughly about $2^1/_4$ g.p.g. of alum and $^1/_2$ g.p.g. of lime. The results are excellent, the color being reduced from the original 40 to 80 p.p.m. down to 2 to 4 p.p.m. in the filtered effluent which, of course, more than meets TAPPI's color tolerance for higher grade products.

Chemical costs are somewhat less than $1^1/_2$ cents per 1000 gallons. The water from this treatment plant has met all expectations. Its purity, low color, and lack of turbidity make it excellent for use in the production of high brightness pulps and papers.

The Vibrotor Screen, Sven Fahlgren

The Vibrotor screen is a relatively new screen in this country. Developed in Sweden it is based on experiences from earlier Jonsson vibrating screens. The Vibrotor screen consists mainly of a rotating and vibrating drum placed in a vat. The drum supplied with stainless steel cut plates is supported in two yokes, the yokes in turn supported on spiral springs. The vibration of the screen drum is transferred through the two yokes from two off-balanced shafts driven by two electrically synchronized motors or one motor with chain drive. A small 1-hp. motor rotates the drum.

The screen is an inward flow screen and can be operated with or without overflow. The accepted stock flows out through one of the cylinder trunnions. A strong shower inside the cylinder cleans the screen plate very thoroughly. The screen differs from the old type of rotary screens by a higher vibration frequency which gives the screen higher capacity and requires a minimum of power. It also makes it possible to operate the screen at very high consistencies. The floor space required is very small, approximately 25% of space required for the number of flat screens needed to handle the same capacity.

Effect of Recycling Spent Liquor in Semichemical Pulping, E. L. Keller and J. N. McGovern

A series of neutral sulphite semichemical digestions of quaking aspen was made in which the spent liquor from each digestion was collected and used in the next digestion after fortifying with additional cooking chemicals. All other digestion conditions were maintained constant. Approximately 85% of the total liquor in the digester at the end of the digestion was recovered, and 80% was reused. The specific gravity and total solids content of the spent liquor closely approached maximum or equilibrium values after 10 cycles of reuse. The equilibrium values after 11 cycles were 212 grams per liter of total solids with 114 grams per liter of sulphated ash in comparison with 76 and 44 grams per liter, respectively, after the first cycle. The pulp yield increased from about 74 to 76% in reaching this equilibrium and the pulp brightness decreased from 51 to 47%. The lignin content of the pulps increased slightly but their strength properties did not change during the recycling process.

Routine Fiber Analysis of Pulp, Paper, and Paperboard, Norval F. Wilson

A routine control method for fiber analysis presented, is including the formula for the new Wilson cadmium-type stain used at Alton Box Board Co. A table of color reactions is given which provides the key to identification of all the common papermaking fibers.

An Optical Projection Method for Measuring Fiber Length, Thomas Fyfe

The pulp and paper industry generally realizes at present that an optical or mechanical device is a basic requirement for estimating the fiber length distribution of a given sample. Several methods for measuring fiber length have been described in the literature but for various reasons none has been adopted as standard procedure. A method that has found continuous operation by the author for the routine measuring of fiber length in pulp shipments and paper mill slurries involves the use of a modified microprojector (photographic illustration).

A box with black inside walls and closed on all sides but the viewing end contains the microprojector and measuring screen. The screen is about 28 inches from the microprojector. The field of view is 7 mm. in diameter to permit the measuring of extremely long fibers without having to fix reference points. Most of the steps in the method such as the selection and preparation of sample and slides are of standard fiber analytical technique but they are nevertheless explained in detail. Fiber length is measured by projecting the image of the straightened fibers onto a screen having a concentric scale in 0.5-mm. divisions calibrated for a magnification of 50× (diagrammatic illustration). The center or smallest circle of this scale is subdivided into 0.1 mm. by means of dots that radiate from the center of the circle in eight equally spaced spokes. The shortest fiber measured is 0.1 mm. in length. A fiber length frequency chart is prepared with 0.1-mm. groups from which results are computed (diagrammatic illustration). Results are reported in the form of a curve. Three different graphic methods for reporting results are discussed and the advantage of the cumulative type curve explained (diagrammatic illustrations). The results of a statistical examination of the method are summarized by the following statements:

1. A minimum of 400 fibers (two slides) must be measured in order to get a fiber length distribution that would be reproducible within 0.4 mm. at the 50% point.
2. There was found to be a difference between operators in the measurement of short fibers; 0.1 to 0.5 mm. in length. More recent work indicates that this source of variability can be eliminated.

The Microscopy and Identification of Synthetic Fibers, F. D. Houghton

This paper presents the simple microscopy of the major synthetic fibers (viscose, acetate, and cuprammonium rayons, Nylon, Vinyon, Orlon, and glass) along with chemical and staining tests for confirmatory purposes. Other new fibers are omitted because of their infrequent occurrence in the paper industry.

The general appearance of each fiber under the microscope is illustrated with drawings and photomicrographs and a systematic scheme for analysis is presented. The entire presentation is designed to help the paper chemist with the identification of synthetic fibers, using a microscope and a minimum of chemical equipment, making special techniques and equipment unnecessary.

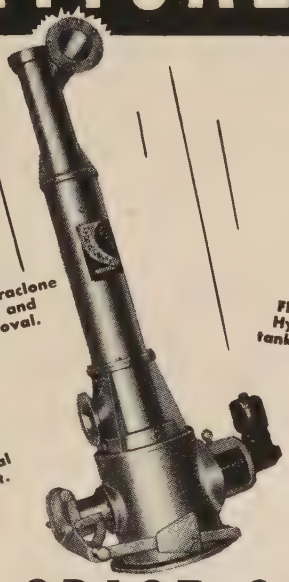
The Microscopic Identification of Paper Fillers, Harold C. Koch, C. Edwin Brandon, and Kenneth P. Geohegan

The identification of mineral fillers in paper is done readily and quickly with the aid of a microscope. The methods of chemical microscopy are rapid and convenient to use. Procedures are given for the recognition of the more common paper fillers, namely: diatomaceous earths, talc, clay and compounds of calcium, zinc, barium, and titanium.

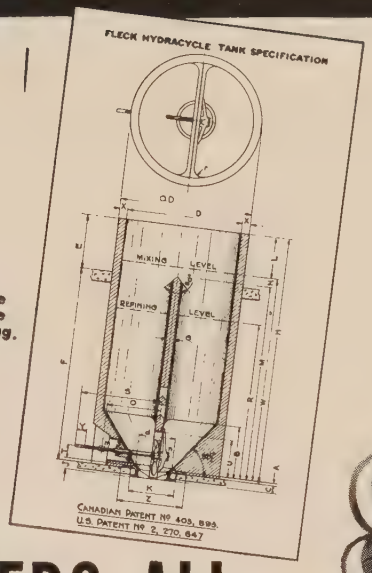
Diatomaceous earths, talc, and clay are recognized by the appearance and size of the particles, when viewed under the microscope. The diatomaceous earths, being the fossil remains of microscopic plants, have characteristic shapes and symmetrical markings. Talc particles are irregular and usually larger than those of clay. Clay is further identified by the presence of flat plates of kaolinite and mica.

The presence of calcium compounds is recognized by the formation of characteristic crystals of calcium sulphate or of calcium

VERTICAL EQUIPMENT



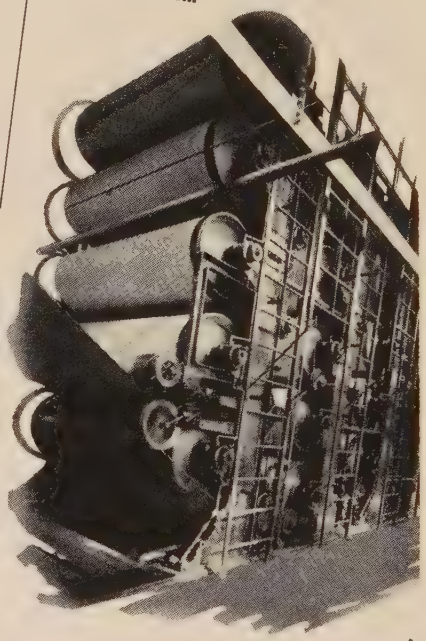
Shartle Hydraclone for sand and grit removal.



Fleck type Hydracycle tank drawing.

Shartle vertical agi-flow unit.

Black-Clawson vertical dryer section.



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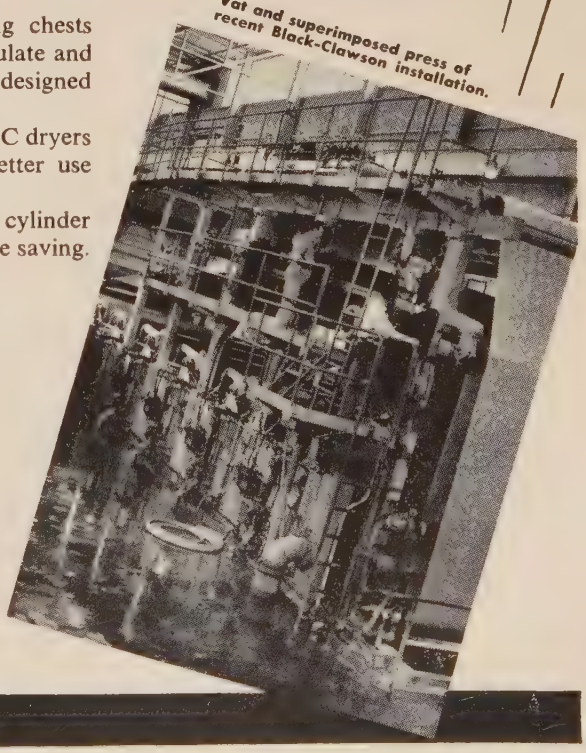
Vat and superimposed press of recent Black-Clawson installation.



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iodate. Calcium sulphates form needlelike crystals which tend to grow into characteristic arrow tail formations. Calcium iodate crystallizes in distinctive, colorless, diamond-shaped crystals.

Zinc thiocyanate crystallizes in the form of feathery crosses which appear black by transmitted light.

Barium sulphate, recrystallized from fuming sulphuric acid, forms crystals which appear as feathery crosses with a marked tendency for two of the adjacent arms to be longer than the other two.

The confirming test for titanium is an adaptation of the qualitative color reaction without the use of the microscope.

Some Unconventional Uses of the Microscope on Wood and its Fibrous Products, T. G. Rochow

The purpose of this paper is to emphasize some unconventional uses of the microscope which may help to make this instrument even more of an aid to the eye in describing and/or identifying products of the pulp and paper industries. Microscopists in these fields are accustomed to using the microscope by transmitted light because separate papermaking fibers are sufficiently transparent and thin. From products which are much more than one fiber thick, usually a "thin" section is cut or ground in order to prepare the specimen for transmitted illumination. Examination by reflected light is less conventional but more convenient and faster, because only one surface need be prepared for examination. A more important result is the microscopical image which is sharper and more contrasty than can be otherwise obtained. The explanation is that the specimen is "optically sectioned" to an illuminated thickness corresponding to the depth of focus, thus practically eliminating out-of-focus, superimposed images. The reflected illumination may be either type: "darkfield" or "brightfield." Darkfield illumination is somewhat more common especially at magnifications under 50× but, because they are produced by scattered light they are less sharp. Photomicrographs will illustrate the above comments.

The determination of optical properties of fibers by reflected light is not yet highly developed but, recently, average refractive indices have been obtained by measuring the proportion of light reflected by the fiber. Perhaps, too, fibers reflect characteristic optical figures as do anisotropic minerals.

The use of ultraviolet light is still unconventional, but it has distinct advantage when there is absorption of certain wavelengths by specific parts of the specimen. For example, melamine-formaldehyde resins happen to absorb strongly around 2537A, the chief emanation of the "2537" mercury lamps. Thus M-F wet strength resins may be located in paper products. Besides quartz refracting objectives, mirror objectives are also available for the job.

A Proposed Card Sorting System for the Identification of Pulpwoods, B. Francis Kukachka

In a recent issue of *Tappi* (33, no. 9: 66A) a universal scheme for wood identification was outlined showing how it could be applied to the identification of species used for pulp and paper. It is, of course, obvious that such a scheme would necessarily be limited in its use to institutions having the necessary IBM equipment. It is apparent also, that a universal key can be used to greatest advantage only when hundreds of species must be taken into consideration and from many foreign countries. Since the pulp and paper industry concerns itself with relatively few native species, the problem of identification does not require the use of a complex, though rapid, system for identification.

A method making use of marginally perforated cards is proposed which aims to simplify and speed the work of identifying the species used in pulp and paper manufacture. The method uses cards having a series of perforations along the margin. Each perforation is assigned a diagnostic character used in identification. The presence of a feature is indicated by notching the card at a particular perforation and its absence by leaving the perforation intact. In actual operation, a short metal rod is passed through a pack of cards at the desired perforation and the pack is then supported by the rod so that cards bearing notched perforations fall from the pack. The number of times this process must be repeated to arrive at an identification will depend largely upon the skill and experience of the operator but will give equivalent results even if the shortest possible route is not followed.

The method of operation is essentially that used in the IBM card sorting scheme and gives the operator the choice of using characters most apparent to him. As with the IBM Key, the number of species contained within the body of key can be increased or decreased as need requires.

Measuring Printing Quality of Magazine Paper, Emery Braugh

The development of the paper specifications for Time, Inc., is outlined and the significant paper qualities that are of importance to them are mentioned. These specifications are tied in with a quality control program that enables a continual check on the performance of every roll of paper supplied and, consequently, has improved their printing efficiency.

Numerical Evaluation of Printability of Paperboard, Clyde Eckhart and L. K. Burnett

Parts of two published methods for determining printability of paper and paperboard have been combined to secure a numerical evaluation of paperboard printability.

Unknown paperboard samples are compared to a standard sample by simultaneous printing from a graduated halftone electrotype. Ink coverage is determined by brightness measurements. Fidelity of image reproduction is measured by visual comparison to ideal printing standards. Combination of these values yields a numerical evaluation of printability.

By this method, the mill learns of variations within a run and from run to run, while the carton printer learns what to expect from each run of board. Results show only limited correlation with physical tests.

Measuring the Printing Quality of Newsprint, G. Larocque, B. Axelrod, and S. Clark

Improved testing equipment and a recommended standard procedure are described whereby newsprint is printed on a proof press under specified conditions of inking, impression, etc., . . . so as to duplicate the appearance which would be obtained with commercial plates and ink on a regular newspaper press. Such a method has the advantage over conventional paper tests (e.g., smoothness, softness, formation, porosity, etc.) in that it measures printing quality directly as such.

Since the conditions which newsprint is called upon to meet in commercial operation vary, depending upon circumstances, the details of this testing procedure have been selected so as to represent the more exacting ones which newsprint must meet in actual commercial practice.

Using this test procedure, the differences in appearance between newsprints are the same as those which would be observed were the papers printed in the pressroom. This test procedure can be used: (1) to show up differences in paper quality from one mill to another, (2) to compare the effect of varying operating conditions at the same mill, and (3) to establish whether a falling off in the appearance of a newspaper can be attributed to pressroom circumstances or to a deficiency in the paper itself.

The quality of the printing can either be appraised visually or, if required, expressed as a number through the use of a conventional reflectance meter. The value which is obtained has been called the "Per Cent Printing Quality" of the paper. On such a scale, the better newsprints test about 83% and the poorer ones 69%, a difference of 14%. Since a difference of 0.4% is readily discernible to the eye, this represents some 35 "least perceptible differences" or distinct steps between the better and poorer papers.

It is suggested that this procedure be used to supplement existing tests in order to assist mill operators in determining what effect changes in furnish and other variables may have upon printing quality, and to permit the production of the best possible grade of newsprint within the practical limitations of wood supply, equipment, and other handicaps which every mill must face. Although intended primarily for testing conventional newsprint, the procedure can also be used for evaluating the effect of new and original techniques of manufacture such as coating or supercalendering newsprint.

A Rotary Pick Tester, Walter W. Roehr

In the printing of both coated and uncoated book papers, the proper pick resistance or surface bonding strength is necessary if optimum printing quality is to be obtained. Until recently the available test methods have not been entirely satisfactory, particularly for some types of pick and on certain types of paper. The present development was undertaken in an effort to construct an improved testing unit and is based, in part, on bonding strength work done by The Institute of Paper Chemistry (Instrumentation Program Report No. 31, Part III). The instrument was designed to simulate to some extent, actual printing procedures and to provide sufficient control of the known variables to permit keeping the tester in statistical control. Fundamentally, it consists of a stationary, rubber-covered impression roll (to which one or more test samples are attached) and a movable black Carrarra glass plate carrying a uniform film of the picking fluid. This arrangement is similar to that of a flat bed cylinder printing press. The plate is driven by a specially designed cam which produces a variable speed proportional to the distance traversed. For the picking medium, a Newtonian fluid, such as blown castor oil, is preferred.

On the theory that the tensile stress applied to the sample surface is proportional to the viscosity of the fluid used and to the speed with which it is pulled away from the surface, a judicious choice of speed range and viscosity permits one to obtain a pick number for every sample run. Among the variables which were found to influence test results are relative humidity, temperature, film thickness, and nip pressure.

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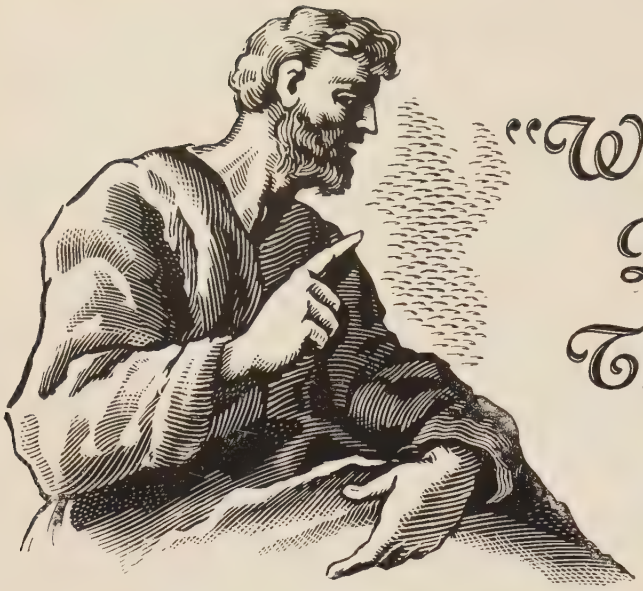

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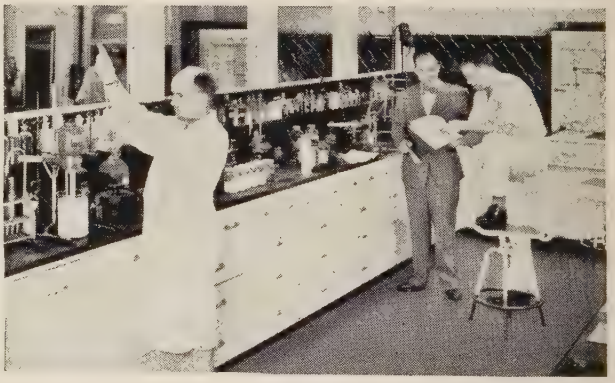
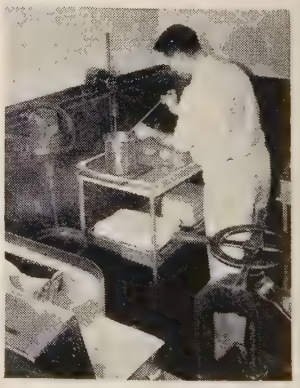


A section of Nopco's paper laboratories

Applying paper coating mixture to hand sheet.



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Bleaching of Neutral Sulphite Semichemical Pulp

S. R. PARSONS and H. J. LAUSMAN

A description is given of the development of bleaching of aspen neutral sulphite semichemical pulp for use in book paper at the Consolidated Water Power & Paper Co. The stages of development included short trials with chlorination bleaching with and without a caustic extraction stage, sodium peroxide used in a single stage and calcium hypochlorite in a single stage. A single-stage calcium hypochlorite bleach was used for an extended period. Data are given for laboratory studies in bleaching semichemical pulp. These data include the effect of alkalinity and the addition of sodium silicate in single stage bleaching with hypochlorites, and the effect of degree of pulping on bleaching conditions. The chlorination-type of bleach for semichemical pulp results in a superior bleached pulp with better strength, higher brightness, and less brightness reversion in storage than for single-stage bleaching. Where a lower brightness pulp is permissable, the single-stage method of bleaching, particularly with calcium hypochlorite, has a great advantage as regards lower cost as compared to the chlorination-type bleach.

THE material discussed herein is based on experience gained at the Consolidated Water Power & Paper Co. in the manufacture and use of aspen bleached neutral sulphite semichemical pulp. Reference is made to an earlier paper by L. W. Murtfeldt on this subject (*1*).

Briefly there are several well-based reasons for the manufacture of semichemical pulp from aspen in the Lake States. Aspen is the only commercial pulpwood growing in the Lake States for which the growth exceeds the drain (*2*). Bleached semichemical pulps are the strongest that can be produced from aspen by commercial pulping processes (*3*). The strongest pulp is not always the most suitable for a given purpose, and pulps produced from aspen by the other pulping processes will find more ready use where a soft bulky pulp is desired. In semichemical pulp we have one that approaches the strength of a coniferous sulphite with consequent sacrifices in bulk and softness.

Semichemical pulp has undergone a rather phenomenal percentage increase in production in the past 10 years. In 1940 the daily production was about 490 tons, in 1950 the production was 2115 tons daily (*4*). Practically the entire production is used in corrugating medium, a small amount is used in specialty board, and small amounts are used in coated book paper and playing card stock.

The differences between the requirements for a semichemical pulp for corrugating medium or other board and that for paper use must be great or else the rapid growth in semichemical production would have included more pulp for use in paper.

Semichemical pulp seems to offer advantages in corrugating medium not fully met by other pulps which gives incentive for its use here. For use in paper semichemical pulp can offer no quality advantage over existing pulps which reduces incentive for its manufacture despite the growing scarcity of the preferred, long fibered wood species in several pulp producing areas.

Two chief difficulties arise in the use of semichemical pulp in paper that are not met in its use in board, viz., difficulty in bleaching and the presence of shives unless the pulp is refined to freenesses lower than desired. Such factors as the preparation of cooking liquor and the cooking presents no problems not already met.

The problem of defibering of the semichemical pulp is outside the scope of this discussion. (In other words the writer has little knowledge on the subject.) Consequently the remarks here are restricted to a discussion of the bleaching of semichemical pulp. (Throughout the following discussion the term semichemical refers to neutral sulphite semichemical pulp.)

A semichemical pulp will seldom have a brightness of over 50 and the pulp will be rather dirty. For most uses in paper it must be bleached. The bleaching of this pulp is complicated by a high lignin content and by pulp freenesses that are generally much lower than desired.

Until fairly recently it has not been considered feasible to bleach semichemical pulp although processes had been suggested in at least one patent (*5*). In a text published in 1941 the statement is made that no satisfactory method of bleaching semichemical pulp is yet known (*6*). Much credit is due to the Forest Products Laboratory and the Solvay Process Co. for their work in developing the bleaching of semichemical pulp to a commercial economic process.

The discussion herein is divided into two sections. The first deals with the commercial production and use of bleaching semichemical pulp, the second to laboratory studies on bleaching.

COMMERCIAL EXPERIENCE

Our first commercial experience in the bleaching and use of semichemical pulp in book paper has been discussed elsewhere (*1*, *7*). The bleaching was accomplished by a two-stage chlorination-hypochlorite bleach. The bleached semichemical pulp was used in amounts as high as 50% with 50% groundwood in making coated book paper. The bleaching was complicated by difficulty in washing caused by slowness of the pulp, particularly after the chlorination stage, and by large amounts of foam in the chlorinated pulp. The strength properties of the bleached pulp were good, and the paper made with as large percentages as 50% of the pulp was of good quality. The main difficulty with this pulp was its slowness, this factor plus a short fiber length gave a low wet strength sheet which resulted in a higher than normal number of breaks on the machine.

S. R. PARSONS, Chief Chemist; and H. J. LAUSMAN, Chemist, Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis.

Table I. Strength Tests on Pulps from Semicommercial Plant

	Beating time, min.	Unbleached 1	Unbleached 2	Unbleached 3	Bleached 1	Bleached 2	Bleached 3
Burst, points per 100 lb.	5	107	107	107	126	139	122
	30	143	137	128	175	174	163
	60	164	163	147	167	175	175
Tear factor	5	1.11	1.09	1.07	1.06	1.16	1.08
	30	1.13	1.01	0.96	0.94	0.85	0.94
	60	0.80	0.94	0.83	0.79	0.79	0.81
Freeness, Canadian Standard	5	590	530	510	400	370	500
	30	435	460	435	135	115	275
	60	265	320	300	110	95	70

Ream Size—24 × 36—500.

The difficulties in the use of semichemical were mainly of an operational nature rather than of adverse effect on paper quality.

It was concluded that the percentage of semichemical pulp in a book paper furnish should be held to a substantially lower quantity than 50%. To offset the slowness of the semichemical pulp consideration was given to the use of groundwood of higher than normal freeness.

effective because of residual acid in the washed pulp from the chlorination stage. One test indicated that about 1.4% caustic soda on the weight of the pulp would be neutralized by the residual acid. If we were to have continued with the chlorination-type bleach, provisions should have been made for better washing to reduce the residual acid.

Strength tests on unbleached and bleached pulp from several days operation are shown in Table I. The

Table II. Effect of pH and Type of Hypochlorite

Bleach No.	Cl_2[a] $Ca(OCl)_2$, %	Cl_2[a] NaOCl, %	NaOH, %	pH Initial	pH Final	Duration min.	Yield, %	Brightness	Strength, (24 × 36—500) Burst, pt./100 lb.	Tear factor	Tensile, p.s.i.	Bulk
1	10	..	1.0	11.4	7.6	40	96.0	65.5	91	1.05	5780	1.47
2	10	..	1.5	11.6	8.2	90	95.6	66.1	87	1.02	6220	1.47
3	10	..	2.0	11.9	8.4	150	95.8	68.7	85	0.94	6310	1.44
4	10	..	2.5	11.8	8.7	190	96.0	69.2	74	0.89	5230	1.48
5	10	..	3.0	11.9	9.2	285	96.5	71.5	76	0.83	5100	1.52
6	10	..	3.5	11.9	9.9	390	96.0	73.5	72	0.78	5750	1.44
7	..	10	1.0	9.5	8.4	45	92.0	68.5	110	1.08	7050	1.36
8	..	10	1.5	10.5	8.5	90	92.5	69.4	104	1.06	6470	1.43
9	..	10	2.0	11.7	8.9	120	92.5	70.3	92	1.02	6610	1.40
10	..	10	2.5	11.9	9.2	190	94.2	70.0	93	1.00	6280	1.40
11	..	10	3.0	12.1	9.6	240	94.7	70.7	91	0.98	7020	1.37
12	..	10	3.5	12.1	9.8	285	94.0	70.0	86	0.84	6130	1.40
Unbleached pulp	..	..	...	...	...	...	...	42.6	103	1.04	7030	1.49

[a]The calcium hypochlorite bleach liquor was saturated with lime. The sodium hypochlorite bleach liquor was adjusted to the same alkalinity (NaOH) as the calcium hypochlorite.
Constant conditions: temperature 100°F. and consistency 10%.

After the construction of a 20-ton per day semicommercial plant at Wisconsin Rapids for the production of semichemical pulp (*1*) several 18 to 20-ton batches were bleached on Sundays in the sulphite bleach plant using a three-stage bleach. In these bleaches the chlorine usage in the chlorination stage varied from 12.8 to 15%. The total chlorine consumption varied from 16.2 to 18.4%. In addition 2% caustic soda was used in the second stage. The lignin contents of these pulps were rather high. The pulp consuming 18.4% of chlorine had a lignin content of 11.4%. Bleached pulp brightness was about 80. The caustic extraction stage was probably not very

bleached pulp is somewhat stronger than the unbleached. The tear for the bleached pulp, however, was not as high as possibly could have been obtained. In some cases this was probably caused by using too much hypochlorite in the third bleaching stage. The data show a general reduction in freeness caused by the bleaching.

The bleached semichemical was used in the manufacture of groundwood book paper. The usage of semichemical was held to about 30%. Groundwood of somewhat higher than normal freeness was used. The results were, in general, very satisfactory with runs made on a relatively slow machine (600 f.p.m.).

Table III. Effect of Varying Amounts of Silicate in Single-Stage Hypochlorite Bleaching

Bleach No.	Silicate, %	pH Initial	pH Final	Duration, min.	Brightness	Strength, (24 × 36—500) Burst pt./100 lb.	Tear factor	Tensile p.s.i.	Bulk
34	0	11.7	9.2	200	68.5	84	1.04	6040	1.47
35	1	11.6	9.3	165	70.2	87	1.08	6150	1.46
36	2	11.6	9.4	145	70.2	91	1.11	6160	1.45
37	4	11.5	9.5	145	70.0	97	1.10	6380	1.44
38	6	11.4	9.5	120	71.3	95	1.08	6230	1.47
39	8	11.2	9.4	105	72.1	92	1.11	6370	1.43
Unbleached pulp	...	...	...	...	44.1	105	1.12	7180	1.46

Constant conditions: 10% calcium hypochlorite, 2.5% sodium hydroxide, 10% consistency, and 100°F. temperature.

On a faster machine (1050 f.p.m.) there were a higher than normal number of machine breaks although the paper quality was satisfactory.

The multistage bleaching of the pulp from the semi-commercial plant was difficult to accomplish because of conflict with the requirements of the bleach plant for the normal bleached sulphite production. Consideration was given to other types of bleaches. Two articles had been published on the single-stage oxidation bleaching of semichemical pulp with either sodium peroxide or hypochlorites (*8*, *9*). These processes appeared promising and mill scale bleaches were made in one case with sodium peroxide and another with calcium hypochlorite. In the former about 18 tons of stock were bleached at a consistency of about 9% with a sodium peroxide usage slightly over 2.5%. The unbleached brightness was 45.7, the maximum bleached brightness was 68.9. The bleaching time was about 7 hours at a temperature of 125°F. About 1.6% sulphuric acid and 9% sodium silicate (all chemical percentages based on moisture-free pulp) were used in the bleaching formula. The bleaching caused a slight decrease in bursting strength and some increase in freeness with little effect on tearing strength.

Twenty per cent of the peroxide bleached pulp was substituted for a like quantity of long fiber sulphite (10% bleached and 10% unbleached) in a book paper furnish with no change in groundwood content. This furnish was run for 12 hours on the machine. The machine ran well with very few breaks. Formation and drainage were good. The strength of the paper was practically identical to that with the normal furnish. However, handsheet tests on stock going to the fan pump showed a slight deficiency in tear. The good drainage characteristics of the peroxide bleached pulp could be attributed in part to the fact that the refining of the unbleached pulp had been limited to a relatively high freeness to avoid the possibility of slow drainage on the machine. This factor coupled with a slight gain in freeness in bleaching gave a relatively free draining pulp. The high freeness in refining was not desirable from the standpoint that the pulp contained some shives.

In the single-stage hypochlorite bleach 10% of chlorine as calcium hypochlorite was used with 2.4% caustic soda to give the desired high alkalinity. The brightness gain was from 47 to 73. The shrinkage was 5%. There was a drop in both bursting and tearing strengths of the bleached pulp and the strengths were below that of the peroxide bleached pulp. The bleaching of shives and dirt appeared slightly better with the hypochlorite than with the peroxide. The hypochlorite bleaching caused a slight drop in freeness, and paper furnishes containing 20% of the bleached semichemical were probably slower draining than the furnishes with the peroxide bleached pulp. The hypochlorite bleached pulp was used in the amount of 20% of the fiber furnish in a book sheet. The 20% of semichemical replaced 5% of groundwood and 15% of bleached long fiber sulphite. The burst was slightly higher and the tear slightly lower than for the standard furnish on 2 preceeding days. Formation and printing were normal for the special furnish.

The possibility existed of temporarily converting to a single-stage bleach for the semichemical pulp by eliminating the caustic extraction stage from the sulphite pulp bleaching and using the caustic cells for semichemical bleaching. If sodium peroxide had been readily available there would have been arguments in its favor, but since peroxide was in short supply conversion was made to a single-stage bleach using calcium hypochlorite to bleach the entire output of the semi-commercial plant. Caustic soda was used to obtain the desired alkalinity and later sodium silicate was used as an additional buffering chemical with apparent benefit on bleached pulp strength. Bleaching consistency was 10 to 12%. The bleached pulp was used in groundwood furnishes in amounts of about 20% of the fiber furnish. Later the bleaching of the semichemical pulp was changed to a method which has been described by Murtfeldt (*1*).

LABORATORY STUDIES OF SEMICHEMICAL PULP BLEACHING

Two general methods of bleaching semichemical pulp are available: (1) the multi-stage chlorination type of bleach and (2) oxidation bleaches. These methods have been discussed in published articles (*8–11*).

Groundwood bleaching with peroxides or hypochlorites is the best known example of the commercial oxidation bleaching of wood pulp. In a pure oxidation bleach there should be no solubilizing of the lignin or other constituents of the pulp. Conventional single-stage hypochlorite bleaching of full cooked chemical pulps does not represent a pure oxidation bleach because chlorination and solubilizing of lignin takes place here. Some solubilizing of lignin takes place in the oxidation bleaches with semichemical pulp but this is usually rather small, and the pulp is left with a considerable lignin residue.

The following agents are commercially feasible for the oxidation bleaching of semichemical pulp: calcium hypochlorite, sodium hypochlorite, sodium peroxide, and hydrogen peroxide.

Fundamentals involved in the use of hypochlorites have been described (*12*, *13*). If calcium hypochlorite is added to a semichemical pulp with no extra alkalinity beyond lime saturation of the bleach liquor a very rapid exhaustion of the hypochlorite occurs with very little brightening of the pulp. This wild reaction may be slowed up to attain better brightness development by the following (*12*, *13*): (1) low temperature, (2)

Table IV. Laboratory Beater Evaluation of Semichemical Pulps

		Unbleached pulp	*Bleached pulp*
Burst Pt./100 lb.	5 min.	129	122
	30 min.	158	149
	60 min.	159	147
Tear Factor	5 min.	1.12	1.02
	30 min.	0.87	0.91
	60 min.	0.69	0.74
Freeness C. S.	5 min.	420	450
	30 min.	285	300
	60 min.	135	160
Burst at 400 freeness		136	134
Tear at 400 freeness		108	99
Time to reach 400 freeness		9 min.	12
Brightness		40.6	69.3

Ream Size—24×36—500.
Bleaching conditions: 10% calcium hypochlorite, 2.5% caustic soda, 4.0% silicate, 10% consistency, 100°F. temperature, 130-minute duration, and 98.1% bleach yield.

Table V. Cooking Results

Cook No.	Chemical[a] Na_2SO_3	Chemical[a] $NaHCO_3$	Chemical[a] Total	Chem. ratio	Cook time, hours	Final pH	Brightness	Lignin, %	Yield, %
320	6.0	1.00	7.00	6:1	4	5.1	55.9	14.61	82.5
315	8.0	1.14	9.14	7:1	4 1/2	5.3	51.5	13.53	76.2
316	10.0	1.43	11.43	7:1	5 1/2	5.9	55.0	11.34	73.0
317	12.0	1.71	13.71	7:1	7 1/2	6.5	59.4	9.96	71.5
318	14.0	2.00	16.00	7:1	10	7.0	58.9	8.73	69.9
319	16.0	2.29	18.29	7:1	14 3/4	7.3	56.9	6.26	67.1

[a] Expressed as Na_2CO_3.
Constant conditions: (1) Chips steamed for 20 minutes; (2) Time to 115°C. = 30 minutes; (3) Time at 115°C. = 2 hours; (4) Time 115–170°C. = 30 minutes; (5) Cook to a residual test of 10 g./l. Na_2SO_3; (6) No pressure relief to 110 p.s.i., then maintained at 110 p.s.i.; and (7) Liquor to wood ratio, 2.6:1.

low consistency, or (3) high alkalinity. Of the above variables the alkalinity is stated as apparently of the most importance.

The oxidation type of bleach is preferably carried out in a single stage. The main benefit obtained by use of more than one stage is that of the added washing. Throughout this discussion the term single-stage bleaching is considered as synonymous with oxidation bleaching. Since the maximum brightness that is feasible by this type bleaching is about 70, the term semibleaching is also applicable.

Variables Involved in Single-Stage Hypochlorite Bleaching

The effect of varying alkalinity on bleaching results with calcium and sodium hypochlorites are given in Table II. These bleaches were made on an aspen semichemical pulp of 7.22% lignin (uncorrected for ash).

Table VI. Single-Stage Hypochlorite Bleaches on Pulps Cooked with Varying Amounts of Chemical

Pulp No.	Time, min.	Bleach yield, %	Brightness	Strength (24 × 36—500) Burst pt./100 lb.	Strength (24 × 36—500) Tear factor	Strength (24 × 36—500) Freeness C. S.	Strength (24 × 36—500) Bulk	Bleached Burst pt./100 lb.	Bleached Tear factor	Bleached Bulk
320	31	98.1	65.3	47	117	690	2.16	58	1.18	1.76
315	70	97.1	67.5	105	99	490	1.63	89	0.96	1.49
316	100	96.7	71.6	113	103	505	1.57	100	0.94	1.49
317	145	98.5	72.5	111	103	610	1.57	97	1.06	1.47
318	170	96.8	73.7	110	102	625	1.54	80	1.01	1.53
319	225	97.4	76.8	123	96	550	1.47	98	0.93	1.35

Constant conditions: 10% calcium hypochlorite, 2% sodium hydroxide, 10% consistency, and 100°F. temperature.

The effect of increasing alkalinity is to increase the bleaching time, increase the brightness, and reduce the bleached pulp strength. The difference between the results obtained with the two types of hypochlorite is so great as to consider them distinctly different bleaching agents. The sodium hypochlorite does not answer the requirements for an oxidizing bleach as well as the calcium hypochlorite, i.e., the sodium hypochlorite causes more solubilizing of lignin. It is apparent that the sodium hypochlorite gives a stronger bleached pulp than does the calcium hypochlorite.

The use of sodium silicate as a buffer in addition to caustic soda seems to have benefit in preserving strength in single-stage hypochlorite bleaches as shown by the data in Table III. These bleaches were made on a pulp of undetermined lignin content (probable 7 to 8% lignin). The silicate used was a 42° Bé grade containing 8.9% Na_2O and 28.9% SiO_2.

While the silicate seems to be of benefit in preserving pulp strength and improving brightness its exact role is difficult to assess. Certainly one effect is to give a mixed bleach of calcium and sodium hypochlorite due to the reaction of sodium silicate with calcium hypochlorite with precipitation of calcium silicate and formation of sodium hypochlorite. The formation of sodium hypochlorite formed in this way is very small, however. The addition of silicate has the effect of reducing the alkalinity as shown by shorter bleaching times and lower initial pH's for increasing additions of silicate.

In the single-stage bleaches the freeness drop usually occurring in the multistage chlorination bleach does not occur. The pulp is easier to handle on a washer after the single-stage bleach than in the unbleached condition. In Table IV are given the results for beater tests on unbleached semichemical and the single-stage bleached pulp. Both pulps were from the same commercial cook.

It would be feasible to use lime rather than caustic soda as a buffer in this type of bleach. However, the lime would cause more difficult washing of the bleached pulp.

Data were obtained that indicated advantages as regards bursting strength of the bleached pulp in using lower consistencies in the single-stage hypochlorite bleaches. Practically, the commercial operation was limited to a minimum consistency of about 10% to insure good circulation of the batch bleachers. Consequently this variable was not explored extensively.

Table VII. Sodium Peroxide Bleaches on Pulps Cooked with Varying Amounts of Chemical

Pulp No.	Bleach Residual peroxide	Bleach Yield	Bleach Brightness	Bleached pulp strength Burst pt./100 lb.	Bleached pulp strength Tear factor	Bleached pulp strength Bulk
320	10.0	96	66.4	60	1.22	1.95
315	10.4	96	65.1	95	0.93	1.59
316	10.6	98	66.6	114	0.94	1.53
317	10.0	100	66.6	116	0.99	1.57
318	10.0	98	66.8	102	1.00	1.60
319	9.0	98	66.9	128	0.95	1.49

Constant conditions: 10% consistency, 4 hours duration, 120°F. temperature, 3% sodium peroxide, 6% silicate, 1% sulphuric acid, and 0.05% magnesium sulphate.

Table VIII. Results of Multistage Bleaches on Pulps Cooked with Varying Amounts of Chemical

Pulp No.	1st Stage Cl₂, %	1st Stage Yield, %	2nd Stage Yield, %	3rd Stage Cl₂, %	3rd Stage Yield, %	Total Cl₂	Total yield on wood	Bleached Pulp Strength Brightness	Burst pt./100 lb.	Tear factor	Bulk	Freeness C.S.
320	18.0	92.4	84.5	5.37	80.8	23.37	66.6	77.2	111	1.13	1.50	385
315	16.0	91.0	83.0	2.42	82.0	18.42	61.6	78.9	123	0.99	1.39	240
316	14.0	93.0	86.7	1.81	85.4	15.81	62.3	79.2	116	0.99	1.33	270
317	13.0	88.8	86.6	1.28	84.0	14.28	60.0	80.3	118	1.04	1.36	370
318	12.0	89.7	85.3	0.95	85.1	12.95	59.4	82.3	126	1.05	1.32	415
319	8.0	95.9	89.6	2.02	88.2	10.02	59.3	80.3	104	0.99	1.40	...

Constant conditions: 1st stage—chlorine gas, room temperature, 2% consistency; 2nd stage—2% caustic soda, 120°F., 10% consistency, 1 hour; and 3rd stage—calcium hypochlorite, 100°F., 10% consistency.

Effect of Degree of Pulping of Semichemical Pulps on Bleaching

A series of semichemical pulps of varying yield and lignin content were produced in the laboratory by using varying amounts of sodium sulphite with a constant ratio of sodium sulphite to sodium bicarbonate of 7 to 1 (both chemicals expressed as sodium carbonate). Single-stage oxidation bleaches with calcium hypochlorite and sodium peroxide, and multistage chlorination-type bleaches were made on these pulps. Roe chlorine numbers were made on the pulps in accordance to TAPPI Standard Method T 205 m-45. The results of this work are given in Tables V to X inclusive.

The softened chips from the several cooks were defibered in a small disk refiner. It was very difficult to refine the small batches of chips to a desired freeness. Consequently there are large variations in the freeness of the several pulps and comparison of strength between pulps from the different cooks is not feasible. However, comparisons can be made of the effect of the several methods of bleaching on the strength of pulp from a given cook.

The peroxide bleached pulps were of somewhat better strength than the single-stage hypochlorite bleached pulps although the difference would have been less if the hypochlorite bleached pulps had been bleached to the same brightness as the peroxide bleached pulps. The strengths of the multistage bleached pulps were fair but probably below what should be expected with this type of bleach.

The data in Tables V and VIII indicate a benefit as regards chlorine economy in cooking to fairly low yields when the pulp is to be bleached by a chlorination bleach. The data for the per cent yield and lignin content of the pulps allow the calculation of the yield of lignin free pulp. These data together with chlorine consumption and total yield data taken from Table VIII are grouped in Table IX.

The pulp from cook 315 was 6.3% lower in yield than that of 320. This reduction represents a large loss in carbohydrate material as evidenced by the large drop in yield of lignin-free pulp. At lower pulp yields the decrease in yield of lignin-free pulp with decrease in lignin content is slight. Purely from the standpoint of chlorine economy there would seem to be a considerable advantage in cooking to relatively low unbleached pulp yields. Lowered unbleached yield does not cause a corresponding decrease in bleached yield. The data in Table IX show less than 1 percentage point lower bleached pulp yield for pulp 319 than for 317 with over 4 percentage points saving in chlorine for pulp 319 as compared to 317. This reasoning does not take into account possible lower pulp strengths at lower unbleached pulp yields or the rather high chemical consumption and long cooking time for the lower yields.

Table IX. Yields and Multistage Chlorine Usage for Pulps Cooked with Varying Amounts of Chemical

Cook No.	Pulp yield, %	Lignin in pulp, %	Yield of lignin-free pulp, %	Total chlorine in multistage bleach, %	Multistage bleached pulp yield based on wood, %
320	82.5	14.61	70.4	23.37	66.6
315	76.2	13.53	65.9	18.42	61.6
316	73.0	11.34	64.7	15.81	62.3
317	71.5	9.96	64.4	14.28	60.0
318	69.9	8.73	63.8	12.95	59.4
319	67.1	6.26	62.9	10.02	59.3

The variation in bleaching time in the single-stage hypochlorite bleaches at constant alkalinity with pulps of varying lignin content is clearly shown by the data in Table VI. The bleaching time, lignin, Roe chlorine numbers, and yield data are compared in Table X. The chlorine number shows a much smaller spread of values than the bleaching times. The bleaching time would seem to offer a fairly good method for determining the degree of pulping of semichemical pulps. The instability of the testing solution and an indefinite end point are drawbacks to such a test.

Difficulties in Single-Stage Bleaching

The single-stage bleached pulps are freer draining than the multistage bleached pulps. This results in higher washer capacity for the former pulps. However, in the case of single-stage calcium hypochlorite bleaching the insoluble calcium compounds are difficult to remove. Also the insoluble calcium compounds may serve as nuclei for pitch (more properly gum in the case of aspen) deposition. However, in commercial operation most of the trouble with pitch deposition seems to occur before the pulp reaches the bleach plant.

The single-stage hypochlorite bleached pulps will be less stable in brightness than is a chlorination bleached semichemical. The single-stage bleached pulp stored in wet lap form may suffer considerable reversion in brightness with long storage times. The reversion is not severe after the pulp is dried. This is illustrated by the following data on brightness sheets read im-

Table X. Comparison of Methods of Determining Degree of Pulping

Cook No.	Yield, %	Lignin, %	Roe chlorine number	Bleaching time in single-stage hypochlorite bleach, min.
320	82.5	14.61	17.9	31
315	76.2	13.53	17.6	70
316	73.0	11.34	14.4	100
317	71.5	9.96	13.4	145
318	69.9	8.73	12.5	170
319	67.1	6.26	10.2	225

Type of bleaching	Brightness 8/29/49	11/4/50
Multistage bleach	81.9	80.9
Single-stage, sodium hypochlorite	68.9	64.2
Single-stage, calcium hypochlorite	71.7	66.2

mediately after the pulp was bleached and on the same brightness sheets after being stored away from the light for 14 months.

CONCLUSIONS

The oxidation type of bleach for semichemical pulp has a definite cost advantage over the multistage chlorination type of bleach. Oxidation bleaching fits the philosophy of semichemical pulping well, i.e., a relatively low cost bleached pulp is produced in high yield. This type of bleach has definite limitations in brightness development, and brightness stability will be poorer than for the multistage bleached pulps. The single-stage bleached pulps will have lower strength than the multistage bleached pulp. The single-stage bleached pulps will usually have higher freenesses and handle easier on washers. In this regard it should be observed that the trouble experienced in the washing of chlorinated semichemical pulp commercially due to slow drainage could be alleviated somewhat by use of a washer designed for the express purpose of handling semichemical pulp. Single-stage calcium hypochlorite bleached pulp while free draining is difficult to wash free of insoluble calcium compounds.

Single-stage bleaching with sodium hypochlorite or with peroxide will give a bleached pulp of better strength and at higher cost than with calcium hypochlorite.

To give incentive to the manufacture of semichemical pulp its cost should be held to the lowest possible value. For grades of paper that permit the use of semibleached pulp the single-stage bleaching of semichemical, particularly with calcium hypochlorite, will produce a bleached pulp of good strength properties at a cost only slightly higher than bleached groundwood of like brightness.

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Received Jan. 2, 1951. Presented at a meeting of the Lake States Section of the Technical Association of the Pulp and Paper Industry, Green Bay, Wis., Nov. 14, 1950.

The Effect of Per Cent Causticity on the Settling Rate of White Liquor

MILTON R. ROBERTS and E. A. HARPER

Several causticizing tests were made using the regular mill supply of lime to the caustic system. The settling rate was noted in each case and the degree of variation was noted in the per cent causticity. The variation was over a range of typical mill operation in order for the tests to show practical information. It was found that as the per cent causticity increased the settling rate was decreased. During the above observations the total alkalinity content remained practically constant. In order to have a more complete picture of the effects of variables on the settling rate of white liquor, a series of tests was conducted in which the total alkalinity was varied and the per cent causticity was adjusted to remain constant. In this case the concentration of the total alkali did not show a marked effect on the settling rate. Therefore, it was the conclusion of the observers that; (1) the per cent causticity does effect the settling rate of white liquor and (2) the total alkalinity does not noticeably effect the settling rate.

Milton R. Roberts and E. A. Harper, Hudson Pulp & Paper Co., Palatka, Fla.

The primary purpose of this paper is to determine the results of variations of causticity and total alkalinity on the settling rate of white liquor. It is hoped that the work performed will be of some indication as to what extent these variables may or may not effect the settling rate and to suggest the best medium for both variables.

The tests performed were on a laboratory scale but they have been proved to be correct by checking the operation of the caustic system on full scale. Green liquor used in the tests was taken from operation and a sufficient quantity was procured in order that all tests would be made using the same batch of liquor. This eliminated the possibility of having error due to changing liquor which may have been of entirely different proportions of the active chemicals in solution. When it was desirable to have variation in the chemical content reagent grade chemicals were added which could be much easier calculated.

The titrations for the A, B, and C tests were made

Table I. Effect of Variation in Causticity

Lime sample, g.	40	80	90	100	110	115	120
Settling time	1 min. 19 sec.	3 min. 18 sec.	3 min. 38 sec.	6 min. 54 sec.	12 min. 11 sec.	13 min. 6 sec.	24 min. 5 sec.
Total alkalinity	1.02	1.02	1.03	1.02	1.04	1.01	1.04
B test	45	70	80	78	82	80	84
C test	53	79	89	87	91	89	94
Na_2S	0.16	0.18	0.18	0.18	0.18	0.18	0.20
NaOH	0.37	0.61	0.71	0.69	0.73	0.71	0.74
Na_2CO_3	0.49	0.23	0.14	0.15	0.13	0.12	0.10
Causticity, %	61.2	72.6	83.5	82.1	85.0	85.4	88.1

in the usual manner, that is, with 0.773 *N* HCl thus giving readings in pounds per gallon without having to use factors for conversion to that expression. Since some mills use other systems of analysis and reporting results, the following review of the test procedure is presented:

1. A Test. The total alkalinity of the white liquor expressed as pounds per gallon as Na_2O. Titration is carried to the methyl orange end point with 0.773 *N* HCl.
2. B Test. All of the sodium hydroxide and $^1/_2$ of the sodium sulphide. This is obtained by precipitation of the carbonate with barium chloride and the titration is carried to phenolphthalein end point with 0.773 *N* HCl.
3. C Test. Total sodium hydroxide and sulphide. This is obtained by continuation of the above titration to a methyl orange end point with 0.773 *N* HCl.

From the above test methods it is possible to calculate the total alkalinity, sodium hydroxide, sodium sulphide, and sodium carbonate. Several methods of expression of results are used in kraft mills for the per cent causticity and sulphidity. In the data presented herein, the per cent causticity is the expression obtained by dividing the hydroxide by the total hydroxide and carbonate. Per cent sulphidity is based on the actual percentage of sulphide in the total alkali.

All the causticizing tests were made in accordance with the methods outlined by the Lime Manufacturer's Association in their literature on testing methods. One liter of green liquor per test was causticized with lime, and the amount of lime was increased for each determination. The regular mill supply of lime was used for all tests. The lime was hand picked to eliminate pieces of lime which did not appear to be as uniform as they should have been in color, size, etc. However, in view of the fact that each batch of lime was probably different in active CaO, the results were not out of line enough to say that the curve of the settling rate would have been little different had C.P. CaO been used. The liquor and lime samples were protected from moisture and evaporation as much as was practical.

The samples of green liquor were causticized at temperatures of 205 to 215°F. as would have been the case in actual mill operations. At this temperature a much faster and more complete rate of causticization is found to be experienced in mill operations. All settling times were checked to 50% of the original volume, the samples cooled to room temperature and tests made to determine the concentrations of the hydroxide, sulphide, and carbonate. Table I shows the average of the first series of tests.

It can be seen, therefore, that the time of settling to 50% of the original volume is greatly affected by the per cent causticity. The settling time is gradually increased on the above tests although in the case of the 90-gram sample more causticization was obtained.

During the above observations no particular attention was given the total alkalinity concentration other than record the information and note that none of the A tests were more than 0.02 pounds per gallon from the average. The sulphidity remained practically the same as was expected. It was necessary to make another series of tests in which the causticity control was maintained constant and the total alkalinity was adjusted each time to be progressively higher by the use of Na_2CO_3. This could have been done also by the use of sodium sulphide. During the tests it was concluded that the settling time would remain constant providing the per cent causticity was constant. The variations of the A test were over a range of 0.90 pounds per gallon to 1.20 pounds per gallon. This range was selected as it takes in practically all liquor concentration noted in a survey of the southern kraft mills.

The results of a back check on the first table of data are listed in Table II. In this series the amount of lime added was kept constant and soda ash was added thus varying the A test and the per cent causticity at the same time.

Table II. Effect of Variations in Causticity and Total Alkali

Settling rate	5 min. 55 sec.	4 min. 45 sec.	4 min. 19 sec.	3 min. 28 sec.
A test	1.04	1.09	1.14	1.19
Causticity, %	83.5	81.2	80.6	79.6
Sulphidity	16.2	16.0	15.5	14.8

In the above table the same amount of lime was added to each of the samples of the determination. Again, it can be seen that the variation of the per cent causticity increase prolongs the settling time which decreases the rate of settling. The variations of total alkalinity in the above table does not seem to have greatly effected the rate of settlement either by retarding or acceleration. This chart gives comparatively the same information as Table I.

By the data presented herein it is concluded that the settling rate of white liquor is influenced by causticities. The total alkali concentration does not greatly effect the settling properties. Causticities of 80 to 85% are maintained for maximum settling rate for efficiency. The A test concentration is usually held from 1.00 to 1.05 pounds per gallon.

The lime used in the system is very influential on the settling rate. A good lime would be one with properties of fast settling and fast reactive in slaking. Usually one is sacrificed, however, this is not always true and some good limes for caustic operations are being sold throughout the south. Another factor which may affect operations is the capacity of the caustic unit. No design of equipment is going to do double its capacity so for maximum efficiency the rated capacity should be maintained.

RECEIVED Dec. 11, 1950. Presented at the Alkaline Pulping Conference sponsored by the Technical Association of the Pulp and Paper Industry, Jacksonville, Fla., Oct. 25-27, 1950.

Selection of Instruments and Controls for Small Steam Power Plants

F. E. HUTTON

THE purpose of instruments and combustion controls is to assist the operator in providing a continuous, adequate supply of steam to the mill at proper pressure, and at the least cost. Continuity and adequacy of steam supply are difficult to evaluate and no attempt to place a dollar value on these factors is to be made here. The decrease in maintenance owing to proper and regular adjustments and lubrication of operating machinery is also difficult to evaluate. However, freeing the boiler plant operator for such attention to his main and auxiliary equipment can unquestionably effect such savings. No attempt to evaluate these savings will be made. The point is made that there are such savings to be made by the installation of automatic boiler plant control equipment.

In order to arrive at some conclusion as to the instruments and automatic controls which may be justified, we can make certain assumptions which in a given plant would be established by test and from records. These assumptions will permit us to evaluate approximately the degree of control justifiable.

The solid lines of Figs. 1, 2, and 3 show assumed efficiencies which might be obtained from coal, oil, and gas fired boiler plants. It is assumed that each plant has two boiler units and that the plant capacities are 25,000 to 100,000 pounds of steam per hour. A sharp break is shown in the efficiency curve of each category at 70,000 pounds per hour capacity. It has been arbitrarily assumed that plants above this capacity would be equipped with economizer and/or air heaters and that those below this capacity would be simple boilers without such auxiliary heat traps. In assuming this breaking point, it is, of course, recognized that many larger boilers will not have such auxiliary heat traps, and some smaller ones will have them depending upon cost of fuel, cost of power, load factor on the steam plant, and other related factors. It will be noticed that a gradually increasing efficiency is shown as the plants grow larger. This assumption is made on the basis that as the size of plant increases, equipment designs, particularly fuel burning equipment designs, are generally superior, having greater attention given to details for regulation and control so that higher efficiencies are obtainable. This is outstandingly true in the case of coal burning equipment. A further break in efficiency of the coal fired unit is shown at the 50,000-pound per hour capacity when it is assumed that dump grates or periodic grate cleaning of the smaller stokers will give way to continuous ash disposal and/or other more or less drastic changes in stoke design. The efficiencies shown are those efficiencies which may be expected under nearly ideal operating conditions which would be obtained with a properly designed and adjusted automatic combustion control of the metering type. Shown in dotted lines on the same figures are the assumed efficiencies which might be obtained with hand control in a plant without adequate meters. The loss in efficiency above 50,000 pounds capacity is shown as 3% for coal firing and represents the additional dry gas loss owing to high excess air or the unburned combustible loss owing to low excess air, increased carbon loss in ash pit, additional loss owing to air infiltration, and loss owing to spurts of excessively high and low rates of firing instead of an average rating closely following the load. Below 50,000 pounds of steam, the hand control efficiency is shown as only 2% less than the automatic control efficiency owing to the lack of refinement in the control means for these smaller units. This has perhaps been stated backward as the hand control efficiencies are in line with the larger units, but the automatic controls are assumed to be able to increase the efficiencies of these smaller units only 2% instead of 3% as is the case of the larger plants. In a similar fashion, the efficiencies for hand control operation for the oil and the gas fired plants have been assumed for all sized plants at $2^1/_2$% less than for automatic control. This assumption of $2^1/_2$% is made, compared to 3% for the coal fired units, on the basis that the variable of carbon loss to the ash pit has been eliminated in the case of gas and oil firing.

Unquestionably many instances of steam plants designed for higher or lower efficiencies than have been assumed may be cited, but it is felt that these efficiencies are representative of accepted practice. Also, many cases may unquestionably be cited where hand control under test has shown efficiencies both better and far worse that those assumed. Certainly the extent to which hand control will approach maximum efficiency obtainable, as represented by efficiency under automatic control, is dependent upon the skill and willingness of the operator, and the help he receives in maintaining his plant equipment in good repair. Another important factor is the character of the steam load to be carried. It will be easier to maintain good operating conditions by hand control if the steam load is constant than if the steam load is variable requiring frequent adjustments and readjustments of the controls. For an existing plant where automatic controls are being contemplated, the present efficiency may be obtained by test and the efficiency possible with metered automatic control may usually be taken as approximately 0.5% lower than the guarantee efficiency under test conditions predicted by the manufacturers. For this discussion, however, the probable improvement in efficiency will be taken as shown on the curves.

F. E. HUTTON, Babcock & Wilcox Co., New York, N. Y.

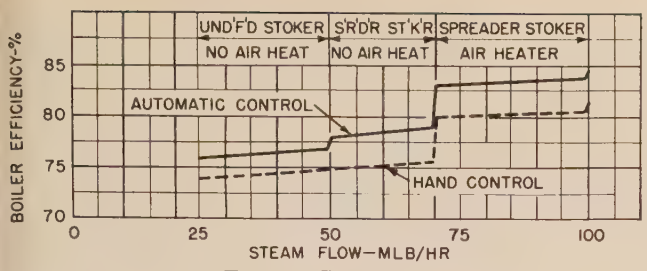

Fig. 1. Coal firing

Assuming that the steam plant will operate on an 80% load factor, the cost of fuel per year has been calculated for both hand and automatic control, the difference being the yearly fuel saving which will be realized by the use of automatic control. The figures for coal are based upon $8.00 per ton of coal having 13,000 B.t.u. per pound, for oil on $1.85 per barrel of oil having 6,000,000 B.t.u. per barrel, and for gas on 20¢ per thousand cubic feet of gas having 1000 B.t.u. per cubic foot. The annual fuel costs on this basis and the annual fuel savings are shown on Figs. 4, 5, and 6.

Speaking in approximate figures, the installed cost of instruments and metered automatic control will be very nearly the same regardless of the size of the plant (assuming two boilers in each case) and regardless of the type of firing. This approximate installed cost would be $9500 exclusive of feedwater regulators which would add $1500 to $2500. The feedwater regulators are installed primarily in the interest of safety and are not to be justified from a fuel saving standpoint. The $9500 may be considered as the cost of combustion control to be balanced against savings in fuel. On the basis in this cost, the time required for the yearly fuel savings to pay for the instruments and controls is shown in Fig. 7. In order to be sure that these curves are not improperly interpreted to show that automatic controls and instruments are more difficult to justify on gas fuel than on other fuels, a fourth curve is shown in dotted lines based on a gas cost of 30¢ per thousand cubic feet instead of 20¢ per thousand, as originally assumed. The relative positions of the three curves, it is seen, and the actual position of each curve, are dependent on the cost of the fuel. As another example, if the cost of coal is halved, the time to pay out will be doubled.

Conservative plant management will frequently demand that the fuel savings alone pay for an investment in 3 to 4 years. This basis of evaluating the desirability of making an investment in combustion instruments and controls is considered by the author to be unnecessarily conservative, as no credit is received for other savings than those to be expected in the fuel bill. Four years as a pay-out period, however,

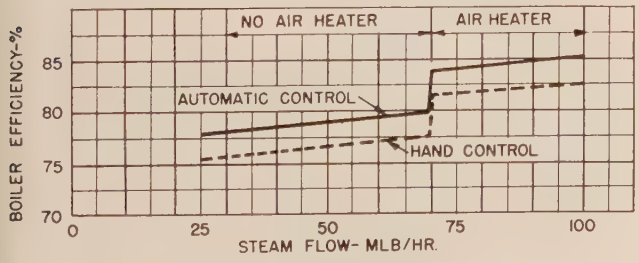

Fig. 2. Oil firing

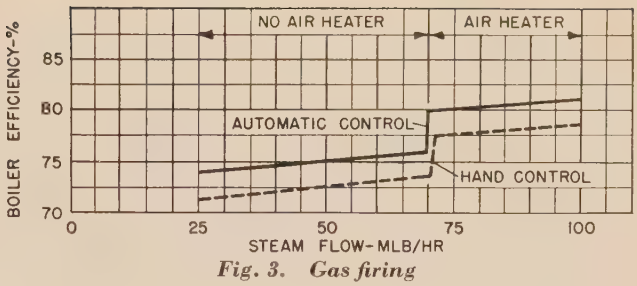

Fig. 3. Gas firing

will be used, in this discussion, as a preliminary guide to economies of a control installation. Such a requirement under the assumed conditions would limit the metering control application to plants above 35,000 pounds per hour for coal, above 29,000 pounds per hour for oil, and above 47,000 pounds per hour for gas at 20¢ per thousand.

The approximate cost of a position automatic combustion control with instruments including a combustion guide and bias adjustment would be $8000. To this should be added, as before, $1500 to $2500 for feedwater regulators which do not contribute to fuel saving. The $8000 is 85% of the cost of the metered control and it is assumed that 85% of the fuel saving on metered control can be accomplished. Since the cost and the fuel savings are reduced in the same ratio, the time to pay out will not be changed.

The approximate cost of a very simple position control with instruments would be $5300 to which must be added, as before, $1500 to $2500 for the feedwater regulators. It is assumed that this control will accomplish 65% of the fuel savings of the metered control. On this basis, the time required for fuel savings to pay out the capital cost is shown in Fig. 8. It will be noted that the simple positioning control pays out in less than 4 years for all sizes of plant down to the smallest under consideration of 25,000 pounds of steam per hour, except with 20¢ gas where a plant of 34,000 pounds of steam per hour is needed to justify the control. Also, it will be noted that the years to pay

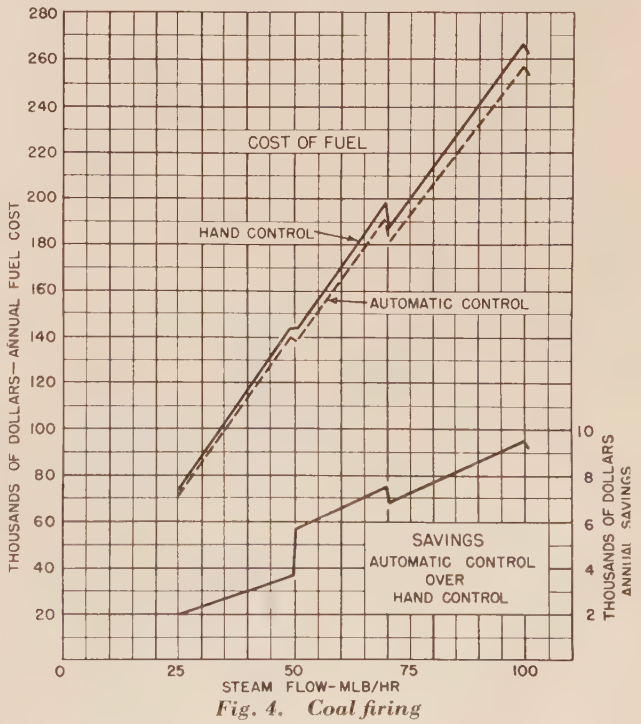

Fig. 4. Coal firing

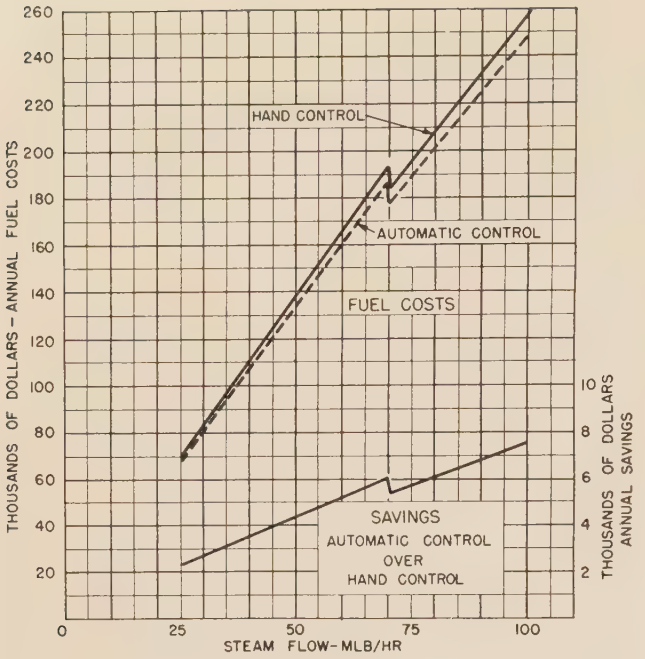

Fig. 5. Oil firing

out the simple positioning control are less for all size plants than the years to pay out the metered control. Using years to pay as the only guide, one would reach the conclusion that the simple positioning control would be the proper choice of all plants in the range of sizes we are considering. However, if we take a different approach and deduct from the annual savings of fuel, a yearly charge to cover the capital costs and maintenance, we will arrive at a net yearly savings as plotted in Figs. 9, 10, and 11. The capital charges made against the savings are:

Ten-year amortization	10% of cost of installation
Interest on investment	6% of cost of installation
Insurance	1% of cost of installation
Taxes	2% of cost of installation
Maintenance	3% of cost of installation
Total capital charges and maintenance	22% of cost of installation

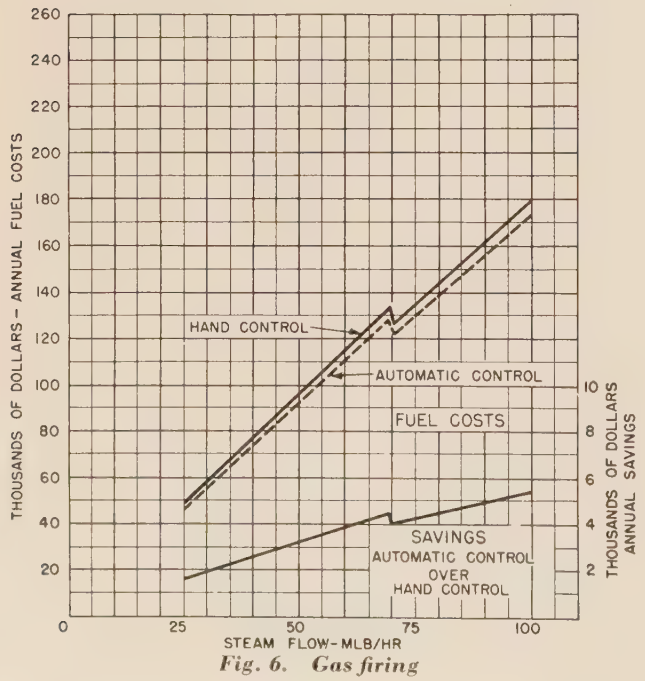

Fig. 6. Gas firing

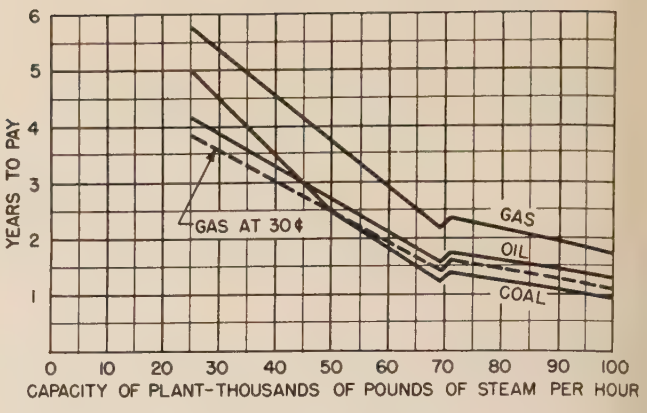

Fig. 7. Metered control—year to pay

Figure 9 shows the net profit per year, for coal firing on this basis, for the three types of controls: (1) metered control, (2) positioning control with combustion guide and bias control, and (3) simple positioning control.

Figures 10 and 11 show the same information for oil and gas firing, respectively.

In these three sets of curves, the positioning control with combustion guide and bias control, that is the guided control, shows a consistently lower net profit than the metered controls and would not be considered. This is not to say that there is not a place under other conditions for the guided control of this type. For instance, under steady load conditions, the guided control may more closely approach the metered control savings and show a greater net profit than the metered control.

It will also be noted that the simple positioning control shows a higher net profit than the metered control for the smaller plants but a lower net profit for the larger plants. Therefore, it would be the author's recommendation, in spite of the arbitrarily calculated greater "years to pay" as shown previously, that the metered control be used for the larger plants because of higher net profits and the simple positioning control be used for the smaller plants where it shows the higher net profits.

For the assumed conditions of efficiency, load factor and fuel cost, these divisions fall as follows:

Coal firing:	Metered control above 35,000-pound plant
Oil firing:	Metered control above 31,000-pound plant
20¢ Gas firing:	Metered control above 43,000-pound plant
30¢ Gas firing:	Metered control above 29,000-pound plant

For a steam plant of two 30,000-pound per hour boilers fired with spreader stokers and for $6.00 coal,

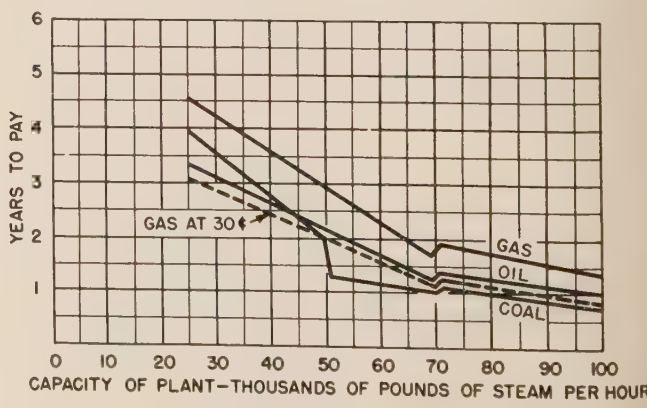

Fig. 8. Simple position control—years to pay

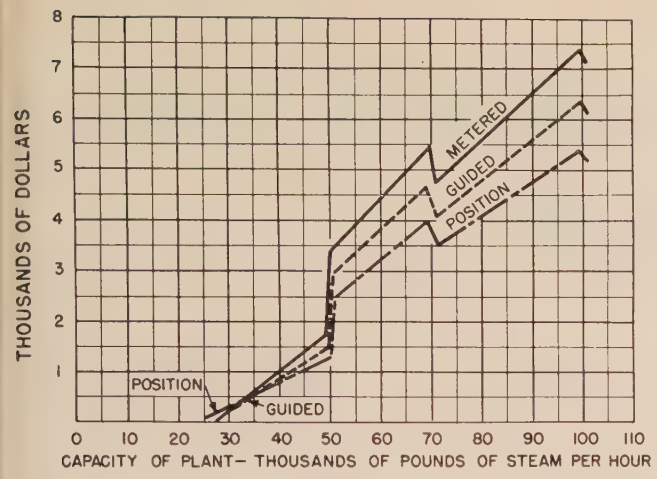

Fig. 9. Profit per year—coal firing based upon fuel savings minus 22% equipment costs

80% load factor, and relative efficiencies as assumed before the author's recommendation for instruments and controls would be the selection of the metered combustion control and instruments as covered by the above discussion and which consists of the following:

Steam pressure gage
Water column gage glass } (Required by ASME Code and not covered in price of instruments and control.)

Draft gages, six pointers, to indicate
- (a) ID fan suction each boiler.
- (b) Furnace draft each boiler.
- (c) Under grate air pressure each boiler.

Temperature recorder, one or two pens to record
- (a) Gas temperature leaving boiler.
- (b) Steam temperature, if superheated.

Temperature indicator to indicate
- (a) Feedwater temperature.

Feedwater regulator, each boiler.

Steam flow meter, each boiler.

Furnace draft regulator to control induced draft fan damper, each boiler.

Master steam pressure controller to establish a control impulse.

Stoker feeder controller to respond to the master steam pressure control impulse, each boiler.

Combustion controller to measure CO_2, excess O_2 or steam flow versus air flow and to establish a bias control impulse for each boiler.

Bias control relay, to relay the original base steam pressure control impulse to the forced draft damper controller and to bias this original impulse as dictated by the bias control impulse for each boiler.

Forced draft damper controller to respond to the biased control impulse received from the bias control relay for each boiler.

Panel board.

Connecting piping and mechanical linkages for controls and damper levers.

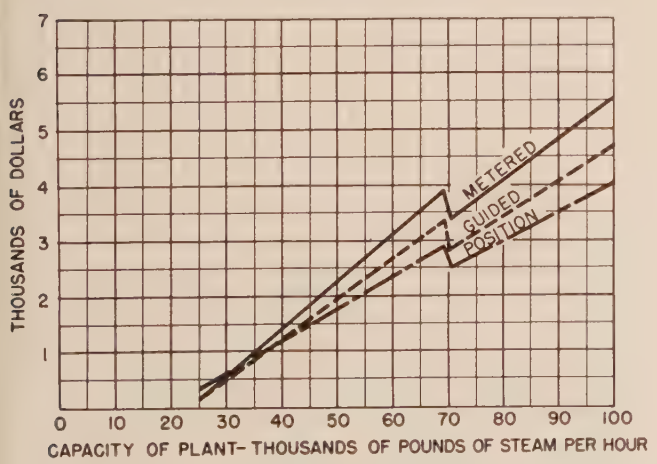

Fig. 10. Profit per year—oil firing based upon fuel savings minus 22% equipment cost

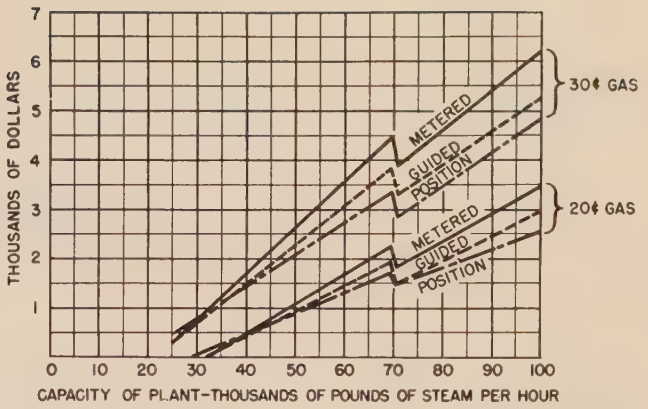

Fig. 11. Profit per year—gas firing based upon fuel saving minus 22% equipment cost

For liquid or gaseous fuels, it should be noted that the same fine adjustment of air supply to fuel supply may be obtained by utilizing a controller designed to measure the fuel flow and the air flow and to establish a control impulse to actuate the forced draft damper controller to maintain a predetermined ratio between the fuel and air flow.

The foregoing would cost approximately $11,750 and the author would offer the following points to his management to gain their approval of his recommendation:

1. Cost of installation of instruments and combustion control ..... $ 9500
2. Cost of feedwater regulator, chargeable to safety of boiler ..... $ 2250
3. Total cost of instruments and control ..... $ 11750
4. Cost of fuel per year without instruments and control based on $6.00 coal $171361
5. Cost of fuel per year with instruments and control based on $6.00 coal $164812
6. Savings per year with instruments and control ..... $ 6549
7. Years for fuel savings alone to pay investment (exclusive of feedwater regulator) 1.45
8. Allowing capital charges for:

Ten year amortization at	10%
Interest on investment at	6%
Taxes	1%
Insurance	2%
Maintenance Charges	3%
Total	22%

then, net saving is $6549 less 22% × $9500 = $6549 − 2090

Annual net profit $4459

9. The boilers are worth some $150,000 and the cost of the feedwater regulator is, as a capital charge at the rate given above, $2250 × 22% = $495 per year which is 1/3 of 1% of the value per year as insurance against lack of attention by the operators and possible serious damage, if not total loss, of the equipment.
10. These instruments and controls will free the operator to watch all of the equipment and auxiliaries for signs of incipient trouble and will permit maintenance and repair while the troubles are minor and while they may be corrected at low expense. A hot bearing lubricated can obviate the replacement of the bearing and the costly shutdown required with the attendant loss of production.

Received March 9, 1950. Presented at the Engineering Conference sponsored by the Technical Association of the Pulp and Paper Industry, Boston, Mass., Nov. 1 3, 1949.

Application Studies on a Cationic Urea-Formaldehyde Wet-Strength Resin

I. J. GRUNTFEST, E. M. YOUNG JR., and V. J. MOSER

Cationic urea-formaldehyde wet-strength resins are now widely used in the paper industry. The importance of their ionic character and degree of condensation in determining performance has been demonstrated. The theory of the action of these resins, however, does not permit prediction of the time the resin must be in contact with the stock in order to obtain optimum results. Similarly the effects of stock dilution at the time of resin addition and sulphate ion in the stock must be examined experimentally. In the present work these important application variables are studied in the laboratory using a typical unbleached southern kraft furnish. It is found, under the selected conditions, that even the most severe practical stock dilutions and short contact times do not interfere with the satisfactory performance of these resins. Further, sulphate ion, which has been found to reduce the effectiveness of the cationic melamine formaldehyde resins has no deleterious effect on the results obtained with this cationic urea resin.

THE rapidly expanding use of wet-strength resins is one of the most spectacular developments in the paper industry today. Completely new products have been developed for this application. There have also been many thoughtful published studies relating to the mechanism of wet-strength development and the retention of resins in the sheet when, as is usual, they are added to the stock before it gets to the wire.

The important elements of the theory as it now stands are as follows. The negative charge on the fibers in the stock suspensions is considered to play a large role in the retention of cationic resins and in the mordanting of anionic resins (*1*, *2*). The molecular weight of the resin determines its sensitivity to coagulation and therefore, to some extent at least its retention by the pulp or the pulp and alum combinations which are used (*1*, *3*). The molecular weight of the resin also determines the distribution of the resin in the finished sheet inasmuch as only lower molecular weight materials have access to the interior of the fibers. It has been shown (*4*) that resin inside the fibers is less effective in producing wet strength than resin situated in the interfiber substance. Furthermore, it appears that if the properties of the resin are such that it cannot blend with the naturally occurring interfiber substance its efficiency is also lowered (*5*). The picture of the mechanism is, however, far from complete and in view of the complexity of the stock system and the severity of the conditions under which the resins are applied it is not likely that the rationalization of their mode of action will be complete for some time.

The complexity of the pulp suspensions is a familiar story. They are heterogeneous systems in which the quantity and quality of pulp surface can vary over a wide range. Both the soluble materials brought in with the pulp and the dissolved substances which occur even in good water supplies can be relatively important constituents of the suspension. The usual additives, such as alum, rosin, and resins are complex materials which are difficult to study even when isolated from the suspensions. Time, temperature, and agitation are also variables which might be important, and these may vary from machine to machine or from time to time on the same machine.

The severity of the application conditions is high lighted by the fact that the resin must be easily soluble and give stable solutions for handling, yet these solutions must be sufficiently unstable so that they are easily and completely coagulated at the extremely high dilutions which occur in the stock. Furthermore the time in which this coagulation must take place may be quite short.

In its present state the theory has been very useful in the design of new resins and in prescribing operating conditions for the resins on the paper machine. It is still quite impossible to predict, however, the time required for the retention determining processes to be completed or the effect of dilution of the stock on these retention processes. The answers to these questions are important in deciding where the resin should be added to the paper machine and they are also relevant to the improvement of the present resins.

The experiments described in this report relate to the application of a commercial cationic urea-formaldehyde resin (Uformite 471). The importance of time and dilution factors is considered. In addition, the effects of sulphate ion, long storage times, and refining after resin addition are examined. The application of the anionic urea-formaldehyde wet-strength resin Uformite 467 is a somewhat different problem since the mordanting action of alum is involved. The performance characteristics of the anionic resin have been the subject of earlier reports (*2*, *6*) and are not elaborated further here.

EXPERIMENTS

Equipment

For the most part standard handsheet techniques were used in the experiments. A description of the equipment, however, will be convenient for explaining the details of the procedures. The setup consists of a $1^1/_2$-pound Valley beater in which the pulp is treated at 2% consistency; storage drums into which the beater is dropped and usually held at 1% pulp solids; a standard disintegrator (TAPPI Standard T 205 m-49) in which the 1% stock is agitated before sheet formation and where additions of resin, rosin, or alum are

I. J. GRUNTFEST, E. M. YOUNG, JR., and V. J. MOSER, Rohm and Haas Co., Philadelphia, Pa.

frequently made; finally another storage tank where dilution to 0.24% pulp solids is made and from which the slurry is metered into the headbox of an 8 by 8-inch Valley sheet mold. The consistency in the headbox of this mold is about 0.05%.

The sheets are couched off the wire with clean blotters, interleaved with dry clean blotters and pressed at 100 p.s.i. for 2 minutes in a Valley hydraulic press. Drying is done under a canvas blanket and a blotter on a photographic print drier operated at 180 to 200°F.

Furnish

An unbleached southern kraft pulp was used. This was beaten to 600 ml. Canadian freeness, which required about 90 minutes using a 2-kg. weight on the bed plate. One quarter of 1% rosin size (Hercules X), 3% alum, and 1% wet-strength resin were added at the disintegrator, except as indicated. The pH of the stock with added alum was 4.7 ± 0.1. Dilution water was adjusted to pH 4.7 with HCl.

Resins

A commercial cationic urea-formaldehyde resin was of major interest in this work. This resin is at present being used on a large scale in many different kinds of furnish and paper. Detailed study in the laboratory was considered worth while because of the greater variety of conditions which are available and the convenience of their control.

In view of the work which has already been published describing the behavior of the cationic melamine formaldehyde resins by Maxwell and others (*1*, *7*) it was considered worth while to conduct parallel experiments with a preparation of that type (Parez 607, American Cyanamid Co.).

Conditions

Pulp consistency at the time of resin addition and contact time were deliberately varied over a wider range than would be encountered on a paper machine so as to produce a more clear-cut experiment. In the first group of tests the pulp solids when the resin was added were varied from 1% to 0.05%, and for each of these, contact times from 25 seconds to 5 minutes were allowed. A few of the sheets were also made as little as 6 seconds after the resin was added.

The experiments were done in groups in which the pulp consistency was held constant. For example, resin was added to 1% pulp at the disintegrator and then sheets were made as rapidly as possible, for the 25-second contact time, by the addition of a measured quantity of the slurry to a prepared headbox. The 1 and 5-minute sheets were also made without the usual intermediate dilution.

Resin was added to 0.24% consistency stock in the intermediate dilution stage and, of course, directly to the headbox to get 0.05% consistency. Naturally shorter times were possible when addition was made directly to the headbox.

All of the sheets were dried on the photographic drier for 10 minutes. One group was then aged in an oven at 300°F. for 30 minutes which is adequate for developing maximum wet strength in the sheet. Another group was held in an air-conditioned room at 70°F. and 65% R. H. and tested after various intervals of so-called natural aging. Both cure periods are artificial; practical wet tensiles are lower than those obtained after the 300° cure and higher than those found after 7 days of natural aging.

Wet tensile tests were made on a Scott IP-4 machine using 1-inch strips which had been soaked in water for 1 hour. Two-inch jaw separation was used.

Table I. Effect of Stock Consistency and Contact Time on Wet-Strength Resin Performance[a]

(1% Resin—Cure: 30 minutes at 300°F.)

Resin-pulp contact time, sec.	*Pulp consistency, %*	*Wet tensile strength,*[b] *lb./in.* *Cationic urea resin*	*Cationic melamine resin*
6[c]	0.05	7.7	7.3
25	1.0	6.7	8.2
	0.24	6.4	7.9
	0.05	6.8	7.0
60	1.0	7.5	8.7
	0.24	8.1	8.3
	0.05	7.0	7.1
300	1.0	7.9	8.7
	0.24	7.8	7.2
	0.05	7.0	6.7

[a] All sheet preparations were done in quadruplicate.
[b] Sheet weight 40 lb. (24 × 36—500).
[c] Except for 6-second sheets, the same drum of stock was used throughout the experiment.

RESULTS

The results of these experiments are shown in Tables I and II.

It appears quite clear from these tables that the pickup of resin is so rapid and easy that even the most severe practical conditions of time and dilution are entirely acceptable. Detailed study of the tables shows that while the shortest times are adequate there may be a slight decay of performance at the lower consistencies. However, such low concentrations are of slight practical concern.

Sulphate Ion

Pursuing further the problems of the practical application of the cationic urea-formaldehyde resin, it has been shown that sulphate anion can seriously interfere with the performance of the melamine formaldehyde resin (*7*). Experiments were therefore set up which would permit an examination of performance of this cationic urea resin in the presence of sulphate ion. Again rather extreme conditions were used in order to give a more clean-cut result. Here again the melamine-formaldehyde resin was run in parallel.

Consistency and time conditions were selected which were in the middle of the range covered in the previous

Table II. Effect of Stock Consistency and Contact Time on Wet-Strength Resin Performance[a]

(1% Resin—Cure: 7 days at 70°F. and 65% R. H.)

Resin-pulp contact time, sec.	*Pulp consistency, %*	*Tensile strength, lb./in.* *Cationic urea resin* *Wet*	*Dry*	*Cationic melamine resin* *Wet*	*Dry*
6	0.05	3.6	20.0	4.0	23.6
25	1.0	3.0	16.8	4.6	18.5
	0.24	2.9	17.1	4.2	18.7
	0.05	2.8	17.2	3.4	16.4
60	1.0	3.7	16.6	4.7	20.4
	0.24	3.2	18.5	4.4	17.9
	0.05	2.4	15.3	3.5	17.5
300	1.0	3.2	18.2	4.2	18.3
	0.24	3.2	19.7	4.2	18.5
	0.05	2.4	17.3	3.6	17.3

[a] Notes on Table I apply here.

experiment, that is resin was added to 0.24% pulp and 1 minute allowed to elapse before sheet formation. Except for the addition of the appropriate amount of sodium sulphate before the resin addition and the omission of alum (for zero sulphate) in one experiment conditions were unchanged from the earlier experiment.

Results are given in Table III.

Table III. Effect of Sulphate Ion on Wet Strength Resin Performance[a]

(1% Resin—Cure: 7 Days at 70°F., 65% R. H., and 30 Minutes at 300°F.)

Na_2SO_4 added p.p.m.—SO_4^{-b}	Alum added	Wet tensile strength, lb./in. Cationic urea resin 70°	300°	Cationic melamine resin 70°	300°
0	0	3.1	6.5	4.1	7.3
0	3	3.2	8.1	4.4	8.3
500	3	3.9	7.5	2.5	5.5
1000	3	3.4	7.4	2.0	3.9
2500	3	3.5	7.0	1.6	3.5

[a] Resin added to stock at 0.24% consistency. Resin-pulp contact time 1 minute.
[b] At 0.24% consistency.

Notice that while the performance of the melamine resin decays markedly as the sulphate increases, the urea resin performance is improved by sulphate addition.

Longer Contact

The experiments which have been done are pertinent where consideration is being given to the metering of the resin into the stock shortly before it hits the wire. If the stock is prepared batchwise or addition is made to a storage chest the resin-pulp contact time can be much longer than 5 minutes and may be several hours. In the next group of experiments, accordingly, longer contact times are allowed.

All compounding of the stock was identical with that used in the first group of experiments except that the additions were made to the stock just before dropping the beater at the 2% consistency. After circulating for 5 minutes the stock was diluted and held for the specified time at 1% consistency. Sheets were made as usual from this stock after 10 minutes in the disintegrator.

The results of two groups of experiments are shown in Table IV. With the cationic urea resin these may be a slight drop in performance after more than 24 hours of contact. A few nitrogen analyses indicate that the retention of the resin is not impaired under these conditions. It is possible that resin aggregation of the type shown by Bursztyn (*5*) could take place and account for the low results.

Table IV. Effect of Longer Contact Times on Wet-Strength Resin Performance

Point of addition	Pulp-resin contact time	Wet tensile strength, lb./in. Cationic urea resin 70°	300°	Cationic melamine resin 70°	300°
Disintegrator	5 min.	3.2	7.9	4.2	8.7
Disintegrator	5 min.[a]	3.4	8.3	2.9	5.8
Beater	30 min.	3.5	8.2	3.5	6.9
Beater	17 hr.	2.9	7.2	2.5	5.8
Beater	41 hr.	2.7	7.5	2.8	5.9
Beater	7 days	1.7	4.7	...	5.8
Beater	30 min.	3.5	7.6	...	...
Beater	2 hr.	3.4	6.8	...	...
Beater	5 hr.	3.4	6.9	...	...
Beater	7 hr.	3.3	7.0	...	...
Beater	24 hr.	2.6	6.4	...	...

[a] Resin added before alum in this one group.

Beating

The last question which has been considered for this report is the effect of refining the stock after the resin has been added. Experiments describing the effect of beating on wet-strength performance have shown that when the beating is done before resin addition (*1*, *6*) there is little or no difference. Beating after resin addition is not considered desirable in the case of the melamine resin (*7*). These experiments were undertaken to get an estimate of the magnitude of the damage which can be done in this way when this cationic urea is used.

Here again two groups of experiments were done. In one conditions were held as close as possible to those used in the earlier experiments. The other set was done in a different connection; an unbleached northern kraft pulp was used with 1.5% urea resin and no rosin. In both 3% alum was the last addition made to the stock.

Table V. Effect of Beating After Resin Addition on Urea Resin Performance

(Cure: 7 Days at 70°F. and 30 Minutes at 300°F.)

Resin, %	Pulp	Time in beater, min.	Addition[a]	Wet tensile, lb./in. 70°F.	300°F.
1	So. kraft	90	Before beating	2.9	6.9
1	So. kraft	90	After beating	3.6	7.6
1.5	No. kraft	30	Before beating	6.0	...
1.5	No. kraft	30	After beating	6.5	...

[a] Three per cent alum added at after beating and after resin in all experiments.

The results shown in Table V indicate that this severe treatment used produced some reduction in wet tensile. The implication is that moderate amounts of refining after the addition of the cationic urea resin are not harmful.

CONCLUSIONS

A laboratory examination of possible sources of operating difficulties in the application of the cationic urea-formaldehyde wet-strength resin has been described. In the experiments, resin-pulp contact times, stock dilution, and sulphate ion concentrations in the practical range were found to be relatively unimportant to wet-strength performance. This demonstration of versatility has been confirmed by successful mill applications involving different furnishes and different points of addition.

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Received Nov. 8, 1950. Presented at the Paper-Plastics Conference sponsored by the Technical Association of the Pulp and Paper Industry, Syracuse, N. Y., Oct. 19–20, 1950.

Super Pure Steam for the Paper Mill with the Dual-Circulation Boiler

H. B. WALLACE, JR.

Paper mill operators have long recognized that the costs of electric power and steam are important considerations in the cost of the paper product. There has been some reluctance in accepting the advantages of steam generation at elevated pressures and temperatures for reasons of high make-up, unfavorable feedwater characteristics, higher heat absorption rates, to mention a few. Boilers operating on the dual-circulation principle developed by the author's firm have been in successful service in a midwest oil refinery over 2 years. This paper will discuss the principles of operation of the dual-circulation boiler, design features of the operating units, correlation of operating results with performance predictions with emphasis on solids and silica vapor carryover and paper mill applications.

MANAGEMENT in the pulp and paper industry is ever mindful that the cost of product is markedly influenced by the cost of steam for process and heat and of electricity for power and light. Such cost-consciousness entails the employment of competent steam-electric plant operating and supervising personnel and the retention of designers thoroughly familiar with the problems incident to the selection of proper and efficient power-plant facilities when additional equipment is involved.

No new trend toward high pressures and higher temperatures has been manifested in the pulp and paper mill power plant in recent years. The pulp and paper industry, as a general classification, has steam and power load requirements which set it apart from others. To some extent, its requirements are not unlike those in the oil refining industry. The balance between steam for process uses and for production of electric energy, however, is shifting, and when the economy of higher pressure as a means of securing incremental power increases evidences a return on the investment, pressures higher than at present are bound to be given serious consideration. In recent years, much emphasis, with encouraging progress, has been placed on feed and boiler water conditioning, on internal treatment, on boiler water circulation, and on steam purification for both industrial and central stations. The accomplishments of the feedwater specialists have been creditable and, in fact, through their efforts as well as of the boiler designer and the boiler operator, the modern high-pressure steam generating unit is possible.

In light of the earlier operating and design problems, the apparent reluctance on the part of paper mill operators in accepting the advantages of steam generation at elevated pressures and temperatures is somewhat understandable. High rates of make-up, unfavorable feedwater characteristics, coupled with higher heat absorption rates once were important factors influencing availability of boiler equipment. Today these factors are still present but control over them has markedly improved to such a state that adoption of higher pressures and temperatures may be made with confidence. For data as a guide to selection of turbine operating requirements, consult a paper by Dixon, Bloomquist, and Wilson (*1*).

It is proposed to present here a new concept of boiler design which is considered to have a field of application in high-pressure pulp and paper mill power plants (600 p.s.i.g. and over); a boiler capable of producing steam of purity hitherto unattainable in a unit of conventional circulation from feedwater containing up to 100% make-up or from feedwater which is high in silica or total dissolved solids content.

The dual-circulation boiler was developed to meet the requirements of an expansion program in a midwest refinery which was confronted with the problems of replacement of uneconomical steam drives with motor drives using inexpensive by-product electrical energy; changes in process design which accounted for reductions in the demand for electric energy. Of several alternatives, the better was the choice between installing condensing turbine generators operating at the existing 400 p.s.i. plant pressure or the installation of topping units to exhaust into the existing 400 p.s.i. system. Adoption of the condensing cycle involved the production of steam for power generation alone with approximately 70% of the heat lost in the condenser. On the other hand, the topping cycle involved only a slight increase in fuel consumption because of the higher pressure and temperature but permitted the generation of the additional power required with no increase in steam production.

As in the case of the usual refinery operations the availability of condensate was very small and the probabilities of contamination and difficulties of collection of this condensate generally advised against its return to the boiler room. With the topping cycle a system involving 100% make-up of boiler feedwater with its attendant treatment and silica carryover problems at pressures above 1200 p.s.i. had to be anticipated. After evaluation of all the factors, the topping cycle was selected with turbines designed to operate at 1250 p.s.i., 900°F. at the throttle and with the treating plant designed to treat 100% make-up water from Lake Michigan in a two-stage hot-process system. In the development of steam generating equipment for this project, the dual-circulation boiler was evolved.

PRINCIPLES OF DESIGN

Figure 1 is a schematic arrangement of the dual-circulation boiler as it might be applied to a unit of

H. B. WALLACE, JR., Manager of Steam Sales, Foster Wheeler Corp., New York, N. Y.

the type having two upper drums. The water wall tubes and the furnace circulatory system constitute the primary or high-duty section. The boiler tubes together with their drums and external circulatory system constitute the secondary or low-duty section. The quantity of feedwater to the unit is the summation of the boiler output and the blowdown to waste. The primary section is blown down continuously, and automatically, at a high rate to the secondary section equal to the amount of steam generated in the secondary section plus the blowdown to waste. Steam generated in the secondary section is delivered to the main drum where it is scrubbed by the main feedwater and is condensed in whole or in part. The condensed portion is returned to the primary section for re-evaporation. The uncondensed steam mixes with the steam generated in the primary section and is delivered to the superheater after being dried. Thus, the principle of stage evaporation upon which the design is predicated is accomplished. In effect, there are two boilers within a single setting with the blowdown from

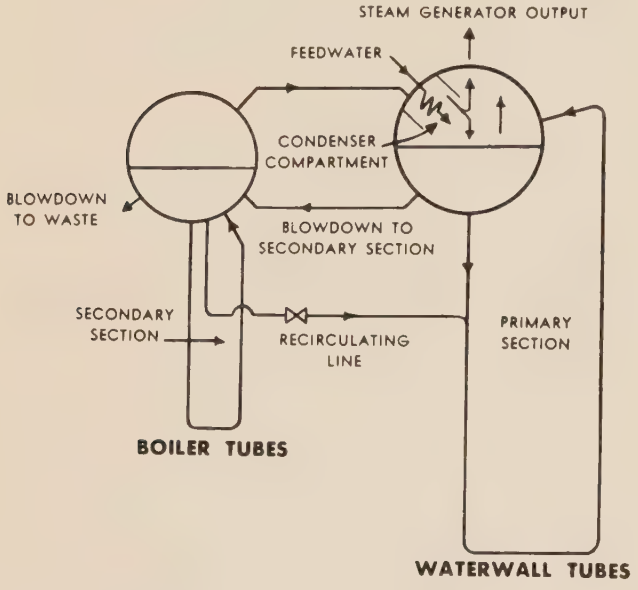

Fig. 1. Schematic arrangement showing principles of dual circulation applied to boiler having two upper drums

the primary boiler providing the feedwater to the secondary boiler. For purposes of controlling pH and hardness, a recirculating line may be provided between the secondary section and the primary section.

While no attempt will be made to go into the derivation of fundamental equations involving material balances in this design, it may be shown that the ratio of boiler water concentrations in the primary section and in the secondary section depends upon the quantity of steam generated in the respective sections and the quantity of blowdown from the secondary section. Since the primary section is blown down at a high rate, its concentration is maintained at a considerably lower value than that of the secondary section which is blown down at a rate necessary to maintain maximum allowable boiler water concentration at values determined practical under actual conditions of operation or as otherwise established for the specific application. Even with high feedwater and make-up concentrations, the hardest worked sections of the unit may be subjected to the high rates of radiant heat absorption with minimum possibility of early formation of scale-forming deposits. Outage time for furnace wall internal cleaning is reduced.

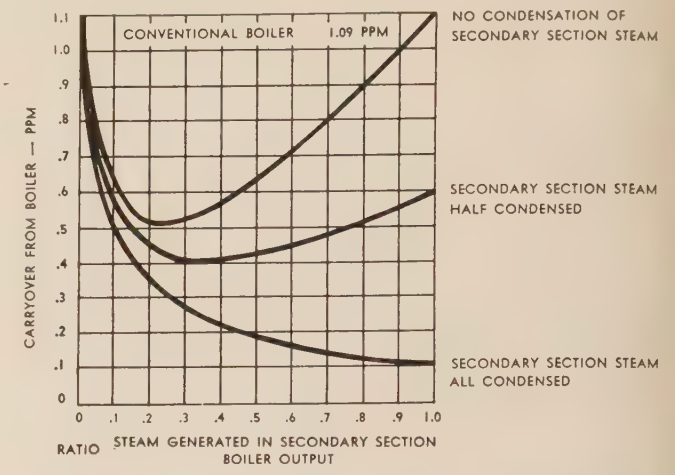
CONVENTIONAL BOILER 1.09 PPM
NO CONDENSATION OF SECONDARY SECTION STEAM
SECONDARY SECTION STEAM HALF CONDENSED
SECONDARY SECTION STEAM ALL CONDENSED
CARRYOVER FROM BOILER — PPM
RATIO STEAM GENERATED IN SECONDARY SECTION / BOILER OUTPUT

Fig. 2. Curve showing effect on carryover for various ratios of steam generated in secondary section of dual circulation boiler to boiler output under conditions of high make-up

It may also be shown from material balances in the dual-circulation boiler in which no washing or condensing of secondary steam is accomplished that the carryover will be minimum when the ratios of blowdown to feed for the two sections are equal. Figure 2 shows the carryover from a dual-circulation boiler for various

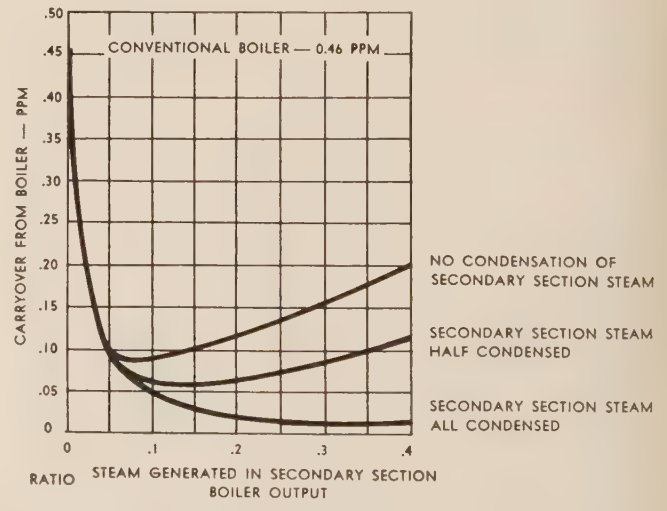
CONVENTIONAL BOILER — 0.46 PPM
NO CONDENSATION OF SECONDARY SECTION STEAM
SECONDARY SECTION STEAM HALF CONDENSED
SECONDARY SECTION STEAM ALL CONDENSED
CARRYOVER FROM BOILER — PPM
RATIO STEAM GENERATED IN SECONDARY SECTION / BOILER OUTPUT

Fig. 3. Curve showing effect on carryover for various ratios of steam generated in secondary section of dual circulation boiler to boiler output under conditions of low make-up

ratios of steam generated in the secondary section and boiler outputs and for various rates of condensation of secondary steam in comparison to the carryover from a boiler of conventional circulation for certain assumed operating conditions as may be experienced in an industrial plant. Figure 3 shows similar curves

for conditions as may be experienced in a central station installation.

For design purposes, the normal ratios of steam generated in the secondary section to the boiler output varies from 0.10 to 0.40. Here it will be noted that since the larger quantity of steam delivered to the superheater is evaporated from boiler water of lowest concentration, the total dissolved solids carryover will be low. Moreover, if silica is present in the feed-

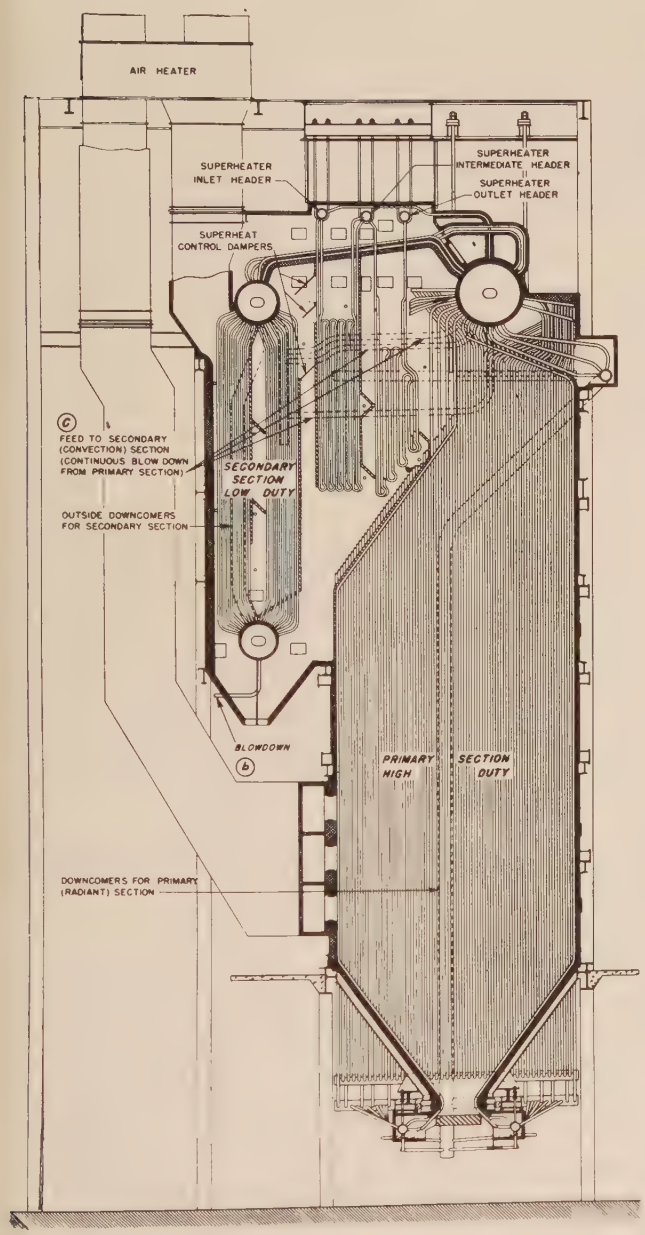
AIR HEATER
SUPERHEATER INLET HEADER
SUPERHEATER INTERMEDIATE HEADER
SUPERHEATER OUTLET HEADER
SUPERHEAT CONTROL DAMPERS
FEED TO SECONDARY (CONVECTION) SECTION (CONTINUOUS BLOW DOWN FROM PRIMARY SECTION)
SECONDARY SECTION LOW DUTY
OUTSIDE DOWNCOMERS FOR SECONDARY SECTION
BLOWDOWN
PRIMARY SECTION HIGH DUTY
DOWNCOMERS FOR PRIMARY (RADIANT) SECTION

Fig. 4. Cross section of three drum dual circulation steam generator installed in a mid-west refinery

water in substantial amount, in the dual-circulation boiler its concentration in the primary section will be substantially lower than in a conventional unit. The amount of silica vaporized in a boiler increases with the pressure, increases with the saturation temperature, increases with the silica concentration of the boiler water from which the steam is released, and decreases as the pH increases. Silica vapor cannot be removed by ordinary drying methods and it passes through the superheater to the turbine where it condenses on the low-pressure stages to a troublesome degree. In the dual-circulation boiler, the contribution by the secondary section in vaporized silica passed to the superheater is well under control depending upon the amount of secondary section steam which is condensed

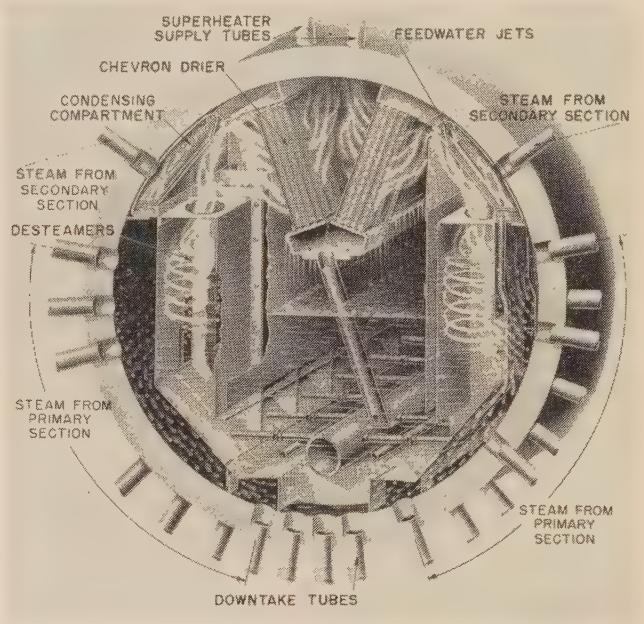

Fig. 5. Arrangement of main steam drum internals used in three drum dual circulation boilers

by the incoming feedwater. Because of the high heat transfer rate from the direct contact between feedwater and steam, the steam will immediately condense. Further, because of the low-silica content of the condensate, the vaporized silica in the steam will return to solution with the condensate. Hence, the amount of vaporized silica from the secondary section added to

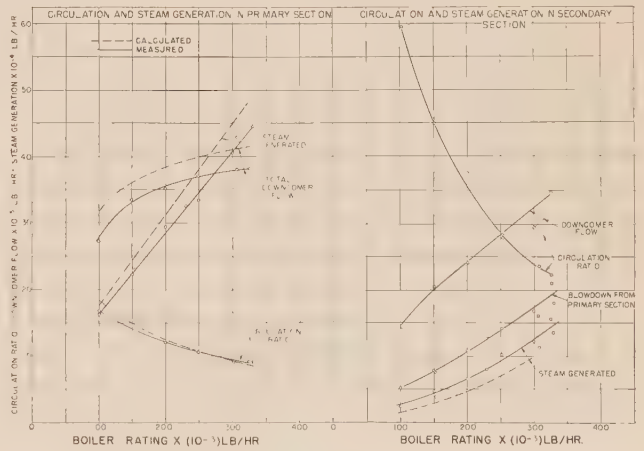

Fig. 6. Circulation data for a three drum dual circulation boiler

that in the steam from the primary will be small. The behavior of silica mentioned herein is based on the work of Straub and Grabowski (*2*).

STEAM DRUM INTERNALS

The separation of the hydraulic circuits in the dual-

circulation boiler is accomplished principally by means of the internals in the main steam drum. The internals generally are designed to perform an additional function, namely, to provide steam-free water to the waterwall circulatory system and to provide water-free steam to the superheater. The necessity for one or two upper drums in the boiler depends in part upon the operating pressure, the feedwater characteristics, and the furnace width. For the initial installation, a boiler of the three-drum type (two upper drums) was selected. One of the four duplicate boilers will be described later. The second installation consisting of three 300,000 pounds steam per hour, 600 p.s.i., 750°F., units were of the two-drum type (one upper drum). Both of these installations are in high make-up oil refinery power stations. The third installation, representing the eighth boiler, currently under construction for a central station, will be of the three-drum type. This unit will be designed for 425,000 pounds steam per hour, 1350 p.s.i., 955°F.

Table I. Comparison of Operation Between Standard and Dual Circulation Boilers Under Conditions of High Make-Up

Drum Operating Pressure Approximately—1500 p.s.i.
Total Soluble Solids Concentration in the Feedwater—150 p.p.m.
Silica (SiO_2) in the Feed—1 p.p.m.
Evaporation in Secondary Section—33% of the Total Output of Boiler

Blow-down, %	Boiler water concentration, p.p.m.			Silica[a] (SiO_2) in boiler water, p.p.m.			Total solids carryover in steam, p.p.m.[c]		Silica (SiO_2) in steam, p.p.m.[d]	
	Standard boiler	Dual circulation boiler		Standard boiler	Dual circulation boiler					
	All tubes[b]	Conventional tubes[b]	Furnace tubes	All tubes	Conventional tubes	Furnace tubes	Standard boiler	Dual-circulation boiler	Standard boiler	Dual-circulation boiler
1	15,150	15,150	445	101	101	2.97	15.1	0.45	1.01	0.03
5	3,150	3,150	415	21	21	2.76	3.2	0.42	0.21	0.028
10	1,650	1,650	384	11	11	2.56	1.7	0.38	0.11	0.026
18	1,000	1,000	352	6.7	6.7	2.36	1.0	0.35	0.07	0.024
20	900	900	340	6	6	2.26	0.9	0.34	0.06	0.023
30	650	650	310	4.3	4.3	2.06	0.7	0.31	0.04	0.021

[a] 10 p.p.m. silica in boiler water recommended as a limit by authorities.
[b] This is also concentration of blowdown water.
[c] Moisture in steam leaving drier 0.1%.
[d] pH = 10.

At the superheater outlet from 100% raw make-up feedwater at 250°F., arranged for oil and gas firing with provisions for future pulverized coal firing to full capacity.

The main steam drum internals of the type used in these units are shown in Fig. 5. Steam of water mixture discharged from the waterwall tubes and risers of the primary section is diverted by means of girth baffles up both sides of the drum shell where it enters the desteamer boxes through vertical tangential slots. Each desteamer is square in horizontal cross section and a strong, whirling core whose diameter varies with the loading, or rate of flow, is induced by the admission of the mixture through the tangential slots. This arrangement is equivalent to a centrifugal separator with a self-adjusting liquid liner. Steam-free water is forced into the corners of the desteamer whence it drains to the water space of the drum without re-entraining steam because of the increased pressure which results from the conversion from velocity head to static head. The steam disengaged at the top of the whirling core leaves the desteamer through a central orifice at the top which is provided to assist in distributing the desteamer loading evenly along the length of the drum and to distribute the loading on the chevron driers. An additional orifice is located near the top of the drum at the upper portion of the

Table II. Comparison of Operation Between Standard and Dual Circulation Boilers Under Conditions of Low Make-Up

Drum Operating Pressure Approximately—1500 p.s.i.
Total Soluble Solids Concentration in the Feedwater—5 p.p.m.
Silica (SiO_2) in the Feed—0.033 p.p.m.
Evaporation in Secondary Section—33% of the Total Output of Boiler

Blow-Down, %	Boiler water concentration, p.p.m.			Silica[a] (SiO_2) in boiler water, p.p.m.			Total solids carryover in steam, p.p.m.[c]		Silica (SiO_2) in steam, p.p.m.[d]	
	Standard boiler	Dual-circulation boiler		Standard boiler	Dual-circulation boiler					
	All tubes[b]	Conventional tubes[b]	Furnace tubes	All tubes	Conventional tubes	Furnace tubes	Standard boiler	Dual-circulation boiler	Standard boiler	Dual-circulation boiler
1	505	505	14.8	3.36	3.36	0.099	0.51	0.015	0.034	0.001
5	105	105	13.8	0.70	0.70	0.092	0.11	0.014	0.007	0.0009
10	55	55	12.8	0.37	0.37	0.085	0.055	0.013	0.004	0.0009
18	32.75	32.75	11.6	0.22	0.22	0.077	0.033	0.012	0.002	0.0008
20	30	30	11.3	0.20	0.20	0.075	0.030	0.011	0.002	0.0008
30	21.65	21.65	10.3	0.14	0.14	0.069	0.022	0.010	0.0014	0.0007

[a] 10 p.p.m. silica in boiler water recommended as a limit by authorities.
[b] This is also concentration of blowdown water.
[c] Moisture in steam leaving drier 0.1%.
[d] pH = 10.

DESIGN FEATURES OF THE OPERATING UNITS

The general arrangement of each of the four units at the midwest refinery mentioned earlier, the first of which has been in successful service nearly $2^1/_2$ years, is shown in Fig. 4. They are designed to produce 300,000 pounds steam per hour at 1350 p.s.i., 900°F.

division plate. The steam from the secondary section is introduced into the condensing compartments of the drum where it may be condensed in whole or in part. Jets of feedwater impinge against a turning baffle to form sheets of water across the tube openings. The mixture of feedwater and condensate from the condensing compartments is introduced into the main section at the center of the drum well removed from the ends where the downtake tubes which provide the continuous blowdown from the primary section to the secondary section are located. The downtakes for the waterwall circulatory system are uniformly distributed along the bottom of the drum. The steam from the primary section plus such steam from the secondary section that is not condensed passes through the chevron driers where the remaining moisture is reduced to innocuous values.

The higher the permissible concentration in the secondary section, the lower the loss in heat in the blowdown. For the same concentration in the waterwall tubes in both the dual-circulation and conventional-circulation boilers, the blowdown necessary to maintain a given value is passed to the secondary section and to waste in the two units respectively. Tables I and II show the benefits which may be derived in reducing total solids carryover and silica carryover in the steam when this design is compared with a standard or conventional circulation design under the several conditions of operation indicated. Note too the marked reduction in the boiler water concentration and silica in boiler water in the furnace tubes. These advantages are especially important in a boiler operating with a high make-up.

The dual-circulation boiler requires no special instrumentation or valves except where recirculation may be required, then one or two small valves are necessary. Boiler water level regulation is identical to a conventionally arranged unit. Chemical control follows normally recommended procedures.

OPERATING RESULTS

Exhaustive tests on circulation and steam purity were conducted on the first operating units shown in Fig. 4 with gratifying results. Figure 6 shows the results of circulation tests. The circulation ratio is the ratio of the water supplied to a section to the steam generated in that section. The tests were conducted with varying water levels with no appreciable change in circulation rates. Table III shows the results of soluble silica in steam and boiler water determinations taken by means of a spectrophotometer. All known precautions were observed to minimize contamination of samples during both test and analysis. While possibly better agreement between anticipated and measured results may be desirable, these data are considered accurate enough to establish the soundness of the principle upon which the design is based.

PAPER MILL APPLICATIONS

This design is not offered as a "cure-all" for paper mill boiler house ills. It is considered to have a paper mill application where the generation of steam of super purity at pressures 600 p.s.i. and higher is under investigation and where feedwater constituents, especially silica may be troublesome in nature. The reduction in blowdown, which is possible under certain conditions, is attractive because of the savings in heat losses and further reflected in savings in chemical treatment. The dual-circulation boiler is a tool by which many of the thermodynamic, chemical, and physical forces influencing high-pressure plant operating conditions may be brought under closer control. Proper application of the design will reflect reduced paper product cost through lower maintenance, higher availability and savings in blowdown, chemical and water treatment costs.

Table III. Soluble Silica in Steam Determined from Tests of Dual Circulation Boiler

Test	*1*	*2*	*3*	*4*	*5*
Boiler rating, M lb./hr.	290	303	211	301	291
Total dissolved solids, p.p.m.					
Feedwater	144	144	144	113	126
Primary section	257	309	278	284	241
Secondary section	918	1990	900	1864	1898
Soluble silica in water, p.p.m.					
Feedwater	2.15	1.80	1.23	1.29	1.17
Primary section	3.14	3.60	2.76	3.39	2.67
Secondary section	10.8	23.3	9.3	23.2	23.42
Blowdown (% boiler rating)					
Secondary section—from Cl	16.2	8.7	...	6.8	5.7
Secondary section—from SiO_2	22.8	8.1	15.5	5.9	5.3
Primary section—from Cl	57.4	56.4	...	43.2	44.6
Primary section—from SiO_2	78.5	52.5	52.5	38.0	46.2
Soluble silica in steam, p.p.m.					
From secondary section—anticipated	0.033	0.054	0.030	0.065	0.065
From secondary section—measured	0.020	0.052	0.039	0.030	0.037
To superheater—anticipated	0.011	0.013	0.012	0.012	0.011
To superheater—measured	0.013	0.023	0.008	0.010	0.009

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Received Dec. 12, 1950. Presented at the Fifth Engineering Conference sponsored by the Technical Association of the Pulp and Paper Industry, Cincinnati, Ohio, Oct. 2–5, 1950.

Development and Construction of a Side Drive Pulper

EDWIN COWLES and JOHN M. KELLY

This paper describes the hydraulic flow characteristics of a fast running, small diameter pulper impeller and shows that the "density of energy dissipation" is an important factor in the pulping and defibering of paper stock. The step-by-step development of the Cowles Side Drive Pulper is briefly described. The final pulper utilizes a 36-inch diameter impeller running at relatively high speed for fast pulping, and the tub is designed to assure good circulation and mixing of stock with practically no splashing, quick submergence of floating material, and fast dumping. The high-speed drive is light and relatively inexpensive and its location permits easy assessibility. The height of the 2000-pound pulper is so low that it can be located directly on top of a stock chest. Handsheets and horsepower per ton per day data are presented for various types of furnish.

THE Cowles Side Drive Pulper described in this paper may be operated continuously or batch-wise but it is particularly intended for the batch pulping of pulp laps, trim, cuttings, broke, and other forms of clean paper stock.

THEORY OF ACTION

At the beginning of the development program the hydraulic action of the Hydrapulper was accepted as being the most efficient action for the pulping and defibering of paper stock. While there is probably some mechanical action present in the Hydrapulper there can be no doubt that most of the action is the result of turbulence in a zone which is immediately above and beyond the impeller vanes. In this zone of turbulence the undefibered stock is separated sheet from sheet, swirled, torn, whipped about, and subjected to a violent fraying action. The suspended solids are also rubbed against each other. This action is peculiarly applicable to pulp and paper stock which is soft when wet but still offers considerable resistance to disintegration.

The violence of this turbulence determines the efficiency and effectiveness of the pulping action. If it is only desired to reduce large pieces of pulp or paper to small pieces the turbulence need not be so violent although it should occupy sufficient space to permit the entrance of the large pieces of stock and to provide the required rate of pulping. As the demand increases for the reduction of the stock in the direction of ultimate defibering the violence and concentration of the turbulence must increase to provide an efficient action. The hardness of a stock or its resistance to defibering also affects the necessary turbulence for an efficient pulping action. Obviously as a stock becomes tougher and harder to break up more action is required.

In designing a pulper, with only these thoughts in mind, the natural urge is to create the required amount of turbulence by establishing the necessary velocity differentials between the stock which is discharged from the impeller vanes and the surrounding stock with no more discharge volume than is absolutely necessary. The reason for keeping the volume of the discharge low is to reduce the power which is required for pumping purposes. A practical way to reduce the volume of discharge is to use low-vaned, small diameter impellers. While such impellers are efficient pulpers, the low discharge volume introduces a problem of maintaining adequate circulation throughout the tub. A small, low-vaned, fast running impeller might well produce the required pulping action to the best advantage but fail completely to keep all of the stock in the tub circulating. It is, of course, most important to keep the entire body of stock circulating as otherwise portions of the stock will not be treated. All of the stock must be a part of a continuous flow pattern so that every bit is caused to pass repeatedly through the zone of action. This explains why the impellers in Hydrapulpers are normally from one third to one half the diameter of the tub. Actually for pulping alone they could range between 20 to 30% of the diameter of the tub. They are made large to insure good circulation and to effect a vortical submergence of floating material. The vanes on these large impellers are kept as low as possible, generally from 1 to 3 inches in height, to keep the pumping load at a minimum while maintaining circulation.

The importance of using an impeller which would provide adequate circulation became apparent at the trials of the first Hydrapulper model in 1938. The impeller in this machine was about one quarter the diameter of the tub. It worked well at consistencies up to about 3%. At higher consistencies the circulation would not extend to the outer section of the tub nor would it reach to the top of the charge at anything more than minimum operating levels. This fault was corrected by increasing the diameter of the impeller. The first commercial Hydrapulper had a 5-foot diameter impeller in a 14-foot tub and the vanes were $1^1/_2$ inches high. The impeller was thus a little more than one third the diameter of the tub.

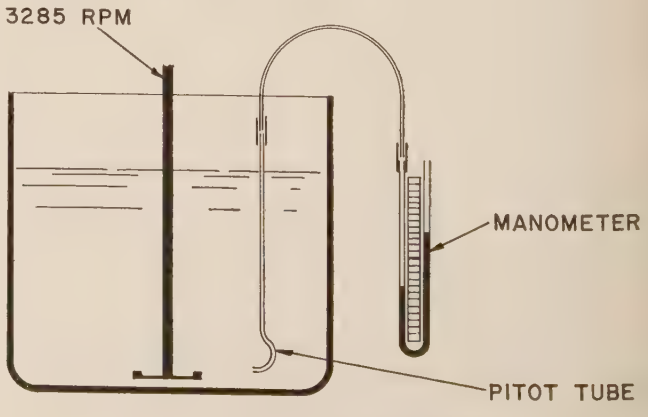

Fig. 1A. Velocity test setup

EDWIN COWLES, The Cowles Co., Cayuga, N. Y., and JOHN M. KELLY, Kelly-Forsyth Co., Ithaca, N. Y.

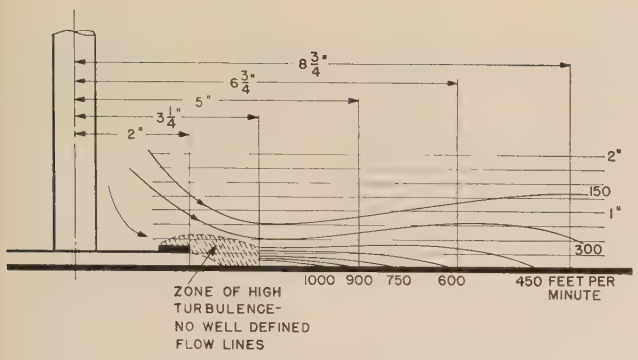

Fig. 1B. Discharge velocities

Attempts have been made to maintain circulation by using smaller impellers having higher vanes. In other words, small, high pumping capacity impellers, but these have not been successful at the higher consistencies.

At first, the interest in smaller faster running impellers had to do with the fact that such impellers and their driving mechanisms were much cheaper to build, but as time went on their greater efficiency became more and more apparent.

About two years ago Victor E. Scottron, then Assistant Professor in Mechanical Engineering and Pure Science in charge of courses in fluid mechanics and aerodynamics at Columbia University, was retained to investigate the hydraulic action of impellers. He conducted a comprehensive series of tests with pitot tubes and other hydraulic testing devices. His results supported the theory about this zone of turbulence immediately above and beyond the impeller vanes and its defibering or pulping action. He further found that the violence of the turbulence was a function of energy dissipated in this zone and the amount of space occupied by this zone. He called this function the "density of energy dissipation." What happens is that as the discharge from the impeller slows down it reacts against the main body of stock to cause the general circulation in the tub. There is, of course, a difference in velocities where the discharge is slowing down and it is this difference in velocities which creates the zone of turbulence. There are such differences in velocity throughout the entire tub but Professor Scottron's work indicated that a very large proportion of the velocity change, turbulence, or energy dissipation as it may be called, occurs immediately above and beyond

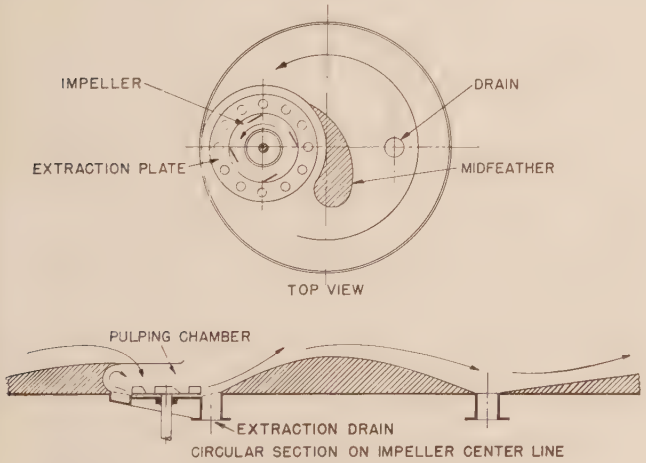

Fig. 2. Offset pulper

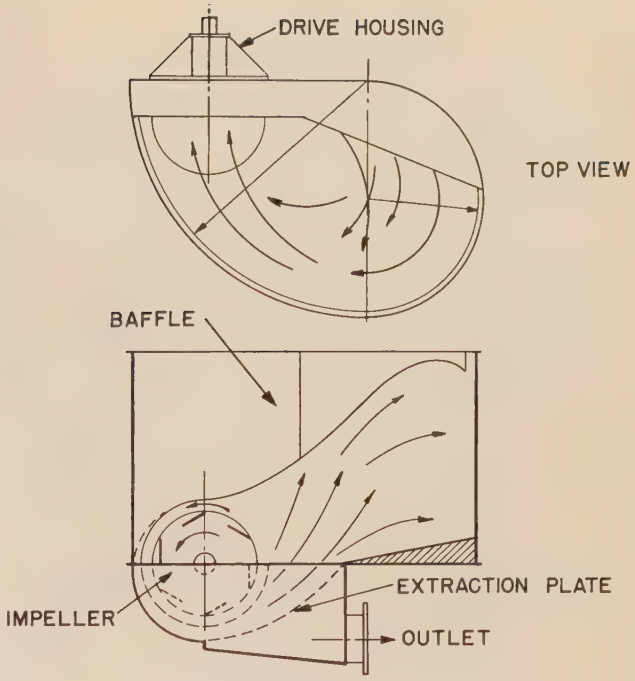

Fig. 3. First side drive pulper

the impeller vanes. It follows that the exact extent of this zone will vary greatly with conditions. With high, slow running vanes it occupies much more space than with low, fast running vanes, and the violence is correspondingly greater with the low, fast running vanes. As previously stated this violence of turbulence must be adjusted to the hardness of the stock and the degree of defibering required for most efficient results. Generally it is desirable to increase this turbulence and yet the amount of power available is limited. A simple way of accomplishing this is by reducing the diameter of the impeller, because the area covered by the zone of turbulence is proportional to the diameter of the impeller. By so reducing the size of the zone of turbulence the intensity of energy dissipation and therefore turbulence is increased accordingly (see Figs. 1A and 1B).

For the simple slushing of soft stock in hot water this violence can be of a low order such as would be set up by an impeller rim velocity of about 2000 f.p.m. For complete defibering of a hard stock in cold water the impeller rim velocity should be up in the region of 7000 f.p.m. At 2000 f.p.m. a typical impeller in a 14-foot

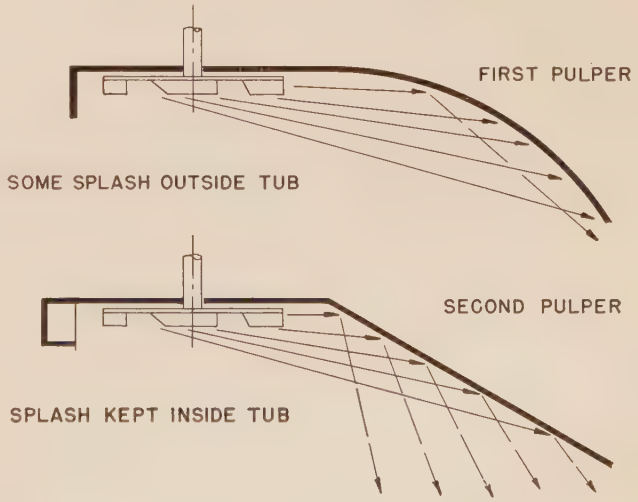

Fig. 4. Revision to back wall

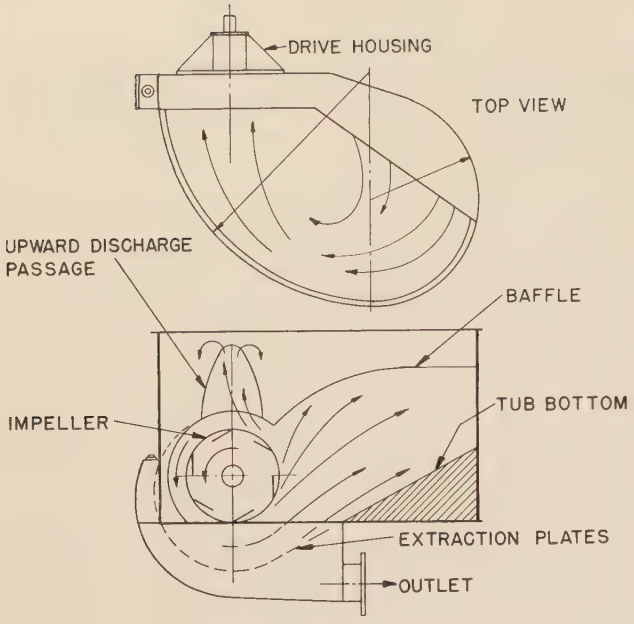

Fig. 5. Second side drive pulper

pulper theoretically will take approximately 25 hp. At 7000 f.p.m. the same impeller would theoretically require something like 700 hp. In the case of the slow running impeller the circulation would fail, and in the case of the fast running impeller the power would be completely out of sight. The result is that, as previously indicated, the pulper designer has to strike a compromise. He would like to put a 2 or 3-foot impeller in a 15-foot tub and adjust the vane heights and speeds to fit the pulping requirements but he would then have faulty circulation.

Another consideration in favor of the smallest possible impeller is concerned with skin friction. Skin friction is the friction between the surfaces of an impeller and the water or stock with which these surfaces are in contact. In the faster running impellers skin friction can result in considerable power loss and the resulting turbulence along the surface does not appear to be violent enough to have much defibering action. In view of the fact that the area or surface of an impeller is a function of the square of the diameter,

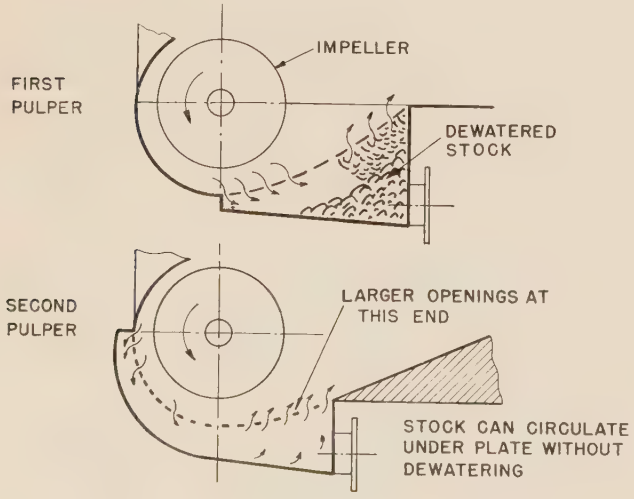

Fig. 6. Revision to extraction chamber

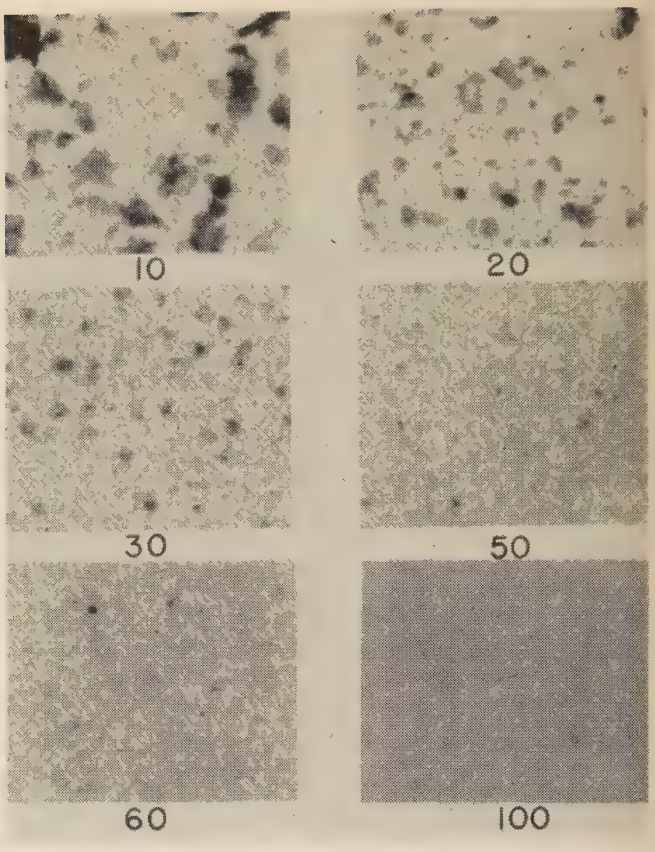

Fig. 7. Cowles defibering standard

the desirability of utilizing the smallest possible impellers again becomes apparent.

IMPELLER TEST DATA

The following data are the result of one of many laboratory tests which were made in studying the action of various impellers and conditions. In this experiment a 6-inch diameter impeller and a 12-inch diameter impeller having the same vane height were selected. The 12-inch impeller was run at a speed which was adjusted to maintain ideal circulation in the tank. The 6-inch impeller was run at a speed which would maintain the same circulation. The tank, consistency, and batch size were the same in both cases. The temperature of the water was 40°F., and overissue news was furnished. Incidentally, old newsprint is very difficult to defiber in cold water. The 12-inch im-

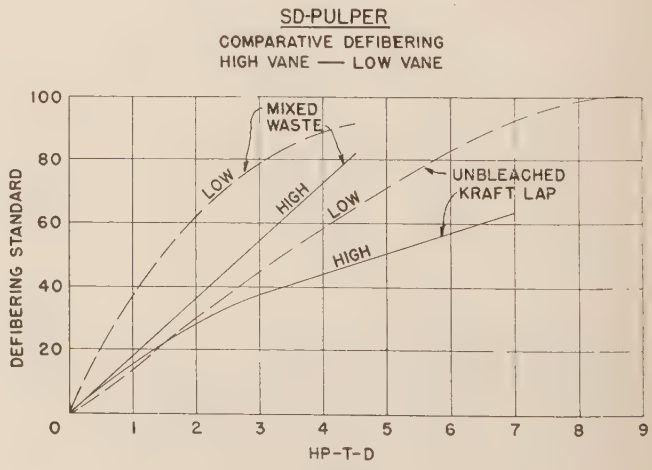

Fig. 8

peller was run at a rim velocity of 1460 f.p.m. and the 6-inch impeller was run at 5200 f.p.m. The larger impeller required 1 kw. and the smaller one required 3.5 kw. The following table gives some of the test data.

Handsheets were made from these samples. Sample II of the 6-inch impeller data was comparable with sample VI-A of the 12-inch impeller data. Sample III of the 6-inch impeller data was better than anything made by the 12-inch impeller. These data indicated that the 6-inch impeller was about twice as efficient as a defiberizer and about one third as efficient as a circulator.

With these facts in mind it was natural to attempt to develop a method of maintaining good circulation and good submergence while using a small, fast running, and therefore more efficient impeller. The second consideration in favor of the small, fast running impeller was that the large impellers and the heavy drive mechanism which they required, because of their low speed and great weight, made the combined impeller and drive assembly a very costly mechanism to build.

The foregoing explains and emphasizes the desirability of developing a pulper, using the Hydrapulper type of pulping action, which will circulate and submerge well while using faster running impellers of approximately one half the size generally used in Hydrapulpers. This led to an effort to find a type of circulation which would be easier to maintain than the vortical circulation of the Hydrapulper.

EQUIPMENT DEVELOPMENT

The idea originated of simply causing stock to rotate in a circular tub. Obviously it was desirable to establish this rotation with a small impeller. About two years ago such a machine, shown in Fig. 2, was built. The tub was 8 feet in diameter, and the impeller was about 16 inches in diameter located in an offset position in the bottom fairly close to the side wall. A barrier was built on the bottom of the tub to collect the discharge from one sector of the impeller and return it to the impeller. The remainder of the discharge from the impeller was left free to travel in its natural direction which was more or less at right angles to a radius drawn through the center of the impeller. A midfeather was added and after a few other changes this machine worked well in every respect. The vortical circulation was established in a section of the tub which was

Sample No.	*Time, min.*	*Kilowatts*	*Tons per day*	*Horsepower per ton per day*
	6-Inch Impeller Data			
I	5	Not slushed enough for sheet		
II	10	3.5	1.8	1.95
III	15	3.5	0.72	4.85
IV	20	3.5	0.54	6.50
	12-Inch Impeller Data			
I-A	10	1.0	Not slushed enough for sheet	
II-A	15	1.0	0.72	1.39
III-A	20	1.0	0.54	1.85
IV-A	30	1.0	0.36	2.78
V-A	40	1.0	0.27	3.70
VI-A	50	1.0	0.22	4.55
VII-A	60	1.0	0.18	5.55
VIII-A	70	1.0	0.15	6.68
IX-A	80	1.0	0.13	7.70

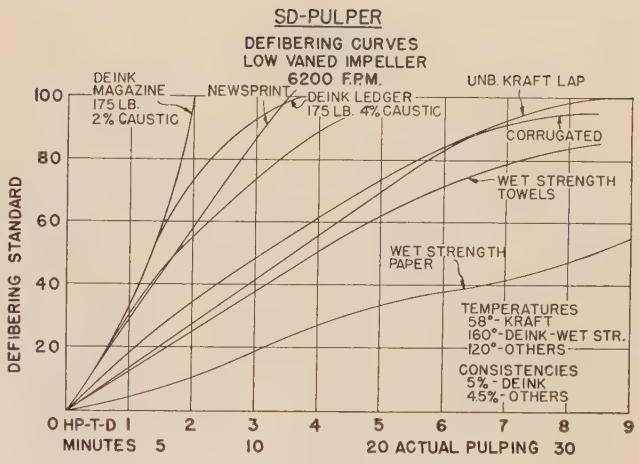

Fig. 9

sufficiently large to accomplish submergence and to keep all of the stock well mixed as it flowed in and out of this section. This design was good but not completely satisfactory. In the first place it had the disadvantage of a vertical drive coming up from underneath or down from up above. The tub was necessarily fairly shallow and therefore required considerable floor area.

The circulating action of the impeller could be further improved if it were mounted on the side wall of the tub with the shaft in a horizontal position. The reasoning was that by so locating the impeller its discharge would be at a tangent to the side of the tub where it would accomplish the strongest rotational effect. In designing the tub for the side drive pulper a departure from a circular shape was made in accordance with Fig. 3. The reason for this was to locate the impeller in such a manner that its discharge would be strictly at a tangent to the circular portion of the tub. Furthermore, it was desirable to take advantage of the circulatory effect of the impeller suction, in other words, the establishment in the tub of a low-pressure area for the returning stock to flow into naturally. A third reason for this shape was to distort the flow pattern to prevent solid materials from lodging in the center of rotation and being held away from the action of the impeller. The curved sections of the tub of this machine had a radius of 2 feet. This, therefore, gave the machine the nominal dimension of a 4-foot pulper. The side walls were 4-feet high. It had a 16-inch impeller which was direct driven by a 10-hp., 720-r.p.m. motor, and would hold 200 pounds of moisture-free stock at 5% consistency. The bottom was sloped to facilitate drainage to a point underneath the impeller.

Referring to Fig. 3 it will be noted that with this design the impeller was shrouded with what amounted to about 70% of the volute portion of the casing of a centrifugal pump. The purpose of this volute was, of course, to collect the discharge from the impeller and to direct this discharge substantially in one direction, horizontally and somewhat upwardly along the side wall of the tub. The cover which would have been present on a centrifugal pump was left off and the clearances around the impeller were purposely made extra large to eliminate any tendency of suspended material to clog in or around the impeller. It will be noted that the inside of the volute was perforated and that there was a chamber in back to collect stock which

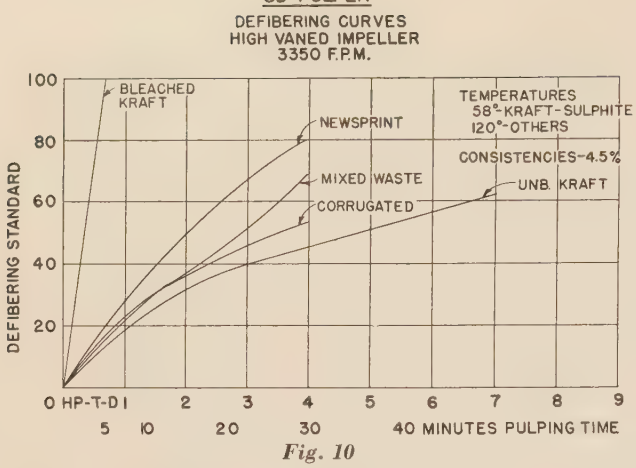

Fig. 10

passed through these perforations. These perforations were for the extraction of stock either continuously or at the end of an operation. The cut-off point or beginning of the volute was curved upwardly to the right to direct the discharge from the impeller. This curve was on a large radius to avoid clogging at this point. This machine performed well and would circulate at 5% consistency with the tub completely full of stock. It also circulated well at all lower levels.

Experience with this machine indicated, however, that certain alterations would still further improve its performance. The drive section wall of the tub which carried the impeller was altered in accordance with Fig. 4 to direct the discharge from the impeller more against the side wall to reduce splashing. The curved surface above the discharge of the impeller was widened out and lastly a decking was put over the drive side of the tub. To improve the submergence, the curved section at this part of the volute was cut away to permit a limited upward discharge from the impeller (see Fig. 5). All edges were sloped and faired away to remove any points or edges where materials might lodge or hang. The bottom was more steeply sloped. The upward discharge spouted up and cascaded down on the surface at a point directly above the inlet to the impeller. The combination of this cascade down onto the surface and the impeller suction immediately below improved the submergence problem at all levels and consistencies. The upward discharge from the impeller also improved the mixing action. The openings at the discharge end of the extraction plate were made substantially larger to permit the free flow of stock from underneath the extraction plate back into the pulper. It had been reasoned that because the pressure on the extraction plate was toward its front end the tendency for the stock would be to flow through the openings at the front end and flow back into the tub through the holes at the discharge end (refer to Fig. 6). Therefore, it appeared that if there was no wash underneath the extraction plate the stock would tend to dewater while passing upward and back into the tub and cause an accumulation under the plate. It was expected that enlarging the opening at the discharge end would remove this tendency, and this proved to be the case as no further trouble was experienced from this source.

TEST PROGRAM

The machine was then tested under a large variety of conditions. Certain corrections were indicated for incorporation into the design of future machines but no further changes were made in the experimental machine.

During the above-mentioned testing program a large variety of furnishes were used. A $^1/_2$-inch vaned impeller was also compared with a 2-inch vaned impeller. The low-vaned impellers were run at a rim velocity of 5700 f.p.m. and the high-vaned impellers were run at a rim velocity of 3200 f.p.m. In the case of the high-vaned impeller the power input was approximately 15 hp. and in the case of the low-vaned impeller the power input was approximately 25 hp. In all cases the circulation and general performance were good at 5% consistency.

In an effort to evaluate quickly the results from the various runs we worked out what we have called the Cowles Defibering Standard. This is merely a series of observation sheets graded at from 10 to 100, 100 being a perfectly clear sheet. These standard sheets were taken at 10 equally spaced intervals from a defibering operation. Since most of the pulping or defibering takes place in the first 10 to 20% of the time required for complete defibering, these do not read in percentages of defibered stock. It is an arbitrary scale. If anything, it indicates the percentage of the power or the time required to do a complete defibering job, however, this is far from accurate as the percentages of power and time will vary greatly with conditions.

Figure 7 shows photographs of six such standard sheets. The photographs were taken with transmitted light to portray the effect of looking through the sheets with a light behind them. In our work ten such sheets are used for purposes of comparison. Only six, 10–20, 30–50, 60–100, are used as to determine the impeller and power specifications for the side drive pulpers. If the 10–20 standard is satisfactory, a 3-inch vaned impeller would be specified. If a 60–100 standard is required then a very low-vaned impeller of special design would be specified. In each

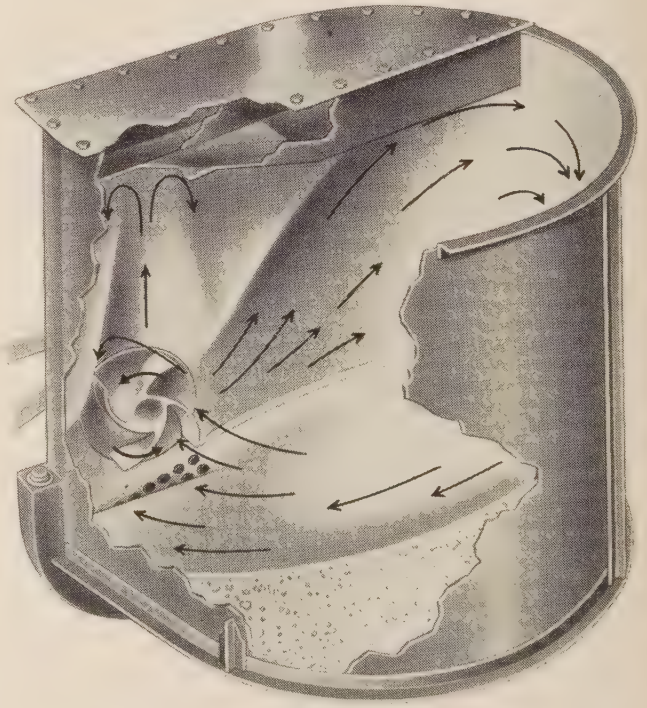

Fig. 11. Cowles pulper

case the power and speed would be adjusted to the conditions. This explains the basic reason for working out this defibering standard. Although only six examples are shown, they are adequate to explain the defibering standard and will make it possible to understand the significance of the following graphs or curves.

Figures 8, 9, and 10 show three sets of curves in which the defibering standard has been plotted against horsepower per ton per day. On the latter two of these graphs the actual pulping time is also shown along with other information of interest.

The first of these graphs (Fig. 8) is a comparison of the high and low-vaned impellers when pulping mixed waste paper and unbleached kraft laps. It will be noted that at 10–20, the low-vaned impeller, shows very little advantage over the high-vaned impeller. Since it calls for more than half again as much connected power, its use is not indicated for such low defibering requirements. The low-vaned impeller shows up to better advantage in the 30–50 range but even so its use is debatable because of the larger amount of power which is required. In the 60–100 range the low-vaned impeller is a must as it is practically impossible to obtain complete defibering with high-vaned impellers when using many furnishes.

The second of the graphs (Fig. 9) shows the defibering performance of the low-vaned impeller when using a wide variety of furnishes. This information should be of considerable interest. It is to be noted that no chemicals were used when treating wet-strength papers. The third of the graphs (Fig. 10) shows similar data for the high-vaned impeller. It is to be noted that bleached sulphite was the only furnish which defibered completely and this one broke down very rapidly.

COMMERCIAL INSTALLATION

At about the time that this series of tests was started arrangements were made with John M. Kelly, President of the Kelly-Forsyth Co. of Ithaca, N. Y., for the installation of such a machine of commercial size in their mill at Port Leyden, N. Y. Figure 11 shows this machine, and it has now been in successful operation for several months. It will hold 1 ton of moisture-free stock at 5% consistency, and the tub has a nominal diameter of 10 feet and a height of 10 feet. The impeller is 36 inches in diameter and has vanes which are 6 inches high; 55 hp. is required. Bleached kraft laps which are very easy to pulp are used in this operation. For more difficult furnishes a lower vaned, faster running, and more highly powered impeller should be used. It is the intention to replace the present 6-inch vaned impeller with one having 3-inch vanes; to increase the speed to about 350 r.p.m. and the power to about 100 hp.

Rolls of rejected paper have been added to this pulper. Although they take quite some time to break up, no difficulty has been experienced.

The machine operates well at all levels and floating materials submerge readily under all conditions.

Received Feb. 16, 1950. Presented at the Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 20–23, 1950.

Redwood Plastic Pulp for Phenolic Resin Laminates

T. A. HOWELLS and R. H. GOMS

In view of the probable shortages of phenolic resins and of conventional pulps, a brief investigation was made of the effect of substituting low-cost redwood "plastic pulp" for one half the kraft pulp in a conventional kraft saturating paper. Handsheets made with 50% plastic pulp had lower tensile strength and poorer water absorbency than those made with all kraft pulp but the alcohol absorbency was not affected appreciably. Laminates made with the 50:50 furnish were weaker than those made with all kraft pulp, but exhibited better bonding and better water resistance at comparable phenolic resin contents or equivalent bonding and water resistance at lower resin contents. The effects of drying or of degree of cooking of the plastic pulp were not as great as was expected from previous experience in other types of applications.

When wood of the California redwood tree (*Sequoia sempervirens*) is cooked by the explosion process, some of the constituents of the wood are converted to a form which has semiplastic properties. This effect has been utilized in a number of applications where the plastic characteristics are useful. Molding compounds can be made with higher percentages of redwood "plastic pulps" and lower percentages of phenolic resins than is true for conventional wood flour-phenolic resin compounds. Preliminary tests indicated that the same resin-extending effect would be evident when plastic pulp is substituted for conventional pulp fibers in the manufacture of papers for saturating with phenolic resins, thereby decreasing the resin content required in the paper-base laminate to obtain a given degree of bonding or water resistance. In view of the low cost ($75 per ton) and availability of the redwood plastic pulp and the impending shortages of phenolic resins, additional work was undertaken with the cooperation of the Pacific Lumber Co. to develop more quantitative data on this effect.

T. A. Howells, Member TAPPI; Research Associate, and R. H. Goms, Technical Assistant, The Institute of Paper Chemistry, Appleton, Wis.

DESCRIPTION OF PLASTIC PULPS USED

From previous work at the Institute and by cooperating companies, it was known that the amount of flow obtainable with plastic pulp can be increased by extending the degree of cooking; this increase in flow is indicated by an increase in the alcohol-soluble content of the pulp. Pulps of three degrees of cooking were furnished by the Pacific Lumber Co. and are designated as "raw," "standard," and "overcooked" pulps. In commercial production, the pulp from the gun has a moisture content of approximately 55%; it is collected in a cyclone and fed to a hot air convection drier which delivers it at a moisture content of approximately 5% to the baling operation. For this

study, pulps of three degrees of dryness were furnished, including pulp taken from the volumetric feeder immediately after the gun, pulp dried to the standard commercial 5% moisture content, and pulp dried to an intermediate moisture content. However, only the two extremes of drying were used in this study. Samples of each of these pulps were analyzed for solubility in cold water, hot water, and alcohol—fresh samples being used for each extraction. The results of these tests are shown in Table I and clearly indicate the effect of cooking upon the alcohol-soluble content.

Fig. 1. Unbleached northern kraft pulp. ×30

As it comes from the gun, plastic pulp will be defibered to a greater or lesser extent depending upon the degree of cooking. For some applications, the presence of fiber bundles will not be a disadvantage. However, for use in papermaking the presence of fiber bundles and the general papermaking characteristics will be important. Bauer-McNett classifications were made on each of the pulps after a standard soaking and disintegration for a total of 1800 counts (approximately 15 minutes) in the British disintegrator. These results are shown in Table II and indicate the decrease in fiber length caused by increased cooking.

PAPERMAKING CHARACTERISTICS

Preliminary trials indicated that handsheets could not be formed with a furnish of 100% plastic pulp unless beaten to a degree that would be objectionable for saturating papers. Beater runs were made using a 50:50 furnish of northern unbleached kraft pulp and the various plastic pulps. Test results are of doubtful quantitative value because of the presence of fiber bundles at low beating times and because of the loss of plastic pulp through the wire, which resulted in a changing composition of the handsheets. Qualitative observations indicated that Williams freeness values (in seconds) increased to a higher value for the 50:50 blends than for the kraft at the same beating time; apparent density, tensile strength, and tear factor were all lower for the blends than for the kraft pulp. In general, the various plastic pulps behaved similarly, with the overcooked pulp yielding a somewhat slower furnish and a denser sheet than the others.

Table I. Soluble Content of Plastic Pulps

Degree of cooking	*Moisture content as received, %*	*Solubility, %*			*pH of cold water extract*
		Cold water	*Hot water*	*Alcohol*	
Raw	47.3	13.6	19.6	21.3	3.9
Raw	10.8	16.5	21.2	22.2	4.0
Standard	38.1	20.8	27.6	34.1	4.1
Standard	8.7	19.7	25.8	34.8	3.7
Overcook	52.1	15.2	23.1	41.0	3.5
Overcook	6.8	17.2	24.3	39.2	3.6

Table II. Bauer-McNett Classification of Plastic Pulps

Pulp identification	*Retained on 10 mesh, %*	*Through 10, on 35 mesh, %*	*Through 35, on 65 mesh, %*	*Through 65, on 200 mesh, %*	*Through 200 mesh, %*
Undercooked, from volumetric feeder	54.6	19.8	4.6	2.3	18.7
Undercooked, dried to 94% oven-dry	53.8	19.6	4.3	2.2	20.1
Standard, from volumetric feeder	31.3	25.8	8.6	5.8	28.5
Standard, dried to 92% oven-dry	35.4	24.3	7.0	4.8	28.5
Overcooked, from volumetric feeder	0.6	5.7	12.8	20.5	60.4
Overcooked, dried to 95% oven-dry	0.4	7.8	16.8	24.6	50.4

In order to prepare handsheets for impregnation, a standard technique was adopted, consisting of one pass through a double disk Bauer refiner set at a clearance of 0.002 inch, followed by screening in a Valley laboratory flat screen with 0.010-inch slots. The accepted material from the screen was collected and used in the preparation of handsheets. As noted in Table III, the percentage of stock accepted by the screen (with or without refining) increases with the degree of cooking; at any given degree of cooking, drying decreases somewhat the percentage of acceptable unrefined pulp but refining eliminates this difference. In a commercial operation, the tailings from this screening operation could be recirculated and reground but this was not done in the laboratory studies. The difference in fiber structure is also obvious from a comparison of Figs. 1, 2, and 3 showing respectively unrefined kraft pulp, standard plastic pulp (refined and screened), and undried overcooked plastic pulp (refined but not screened).

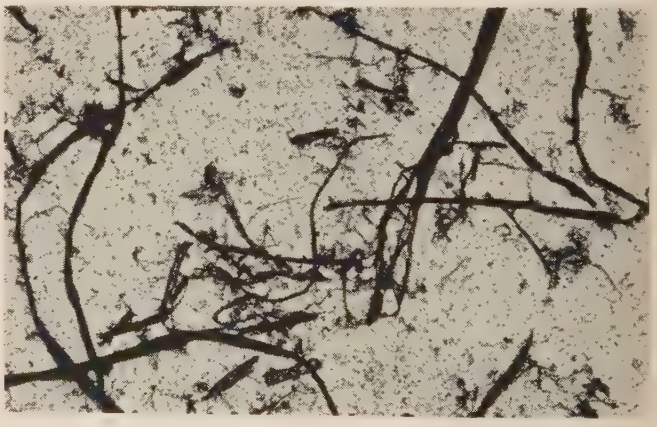

Fig. 2. Standard redwood plastic pulp, refined and screened (photographed dry). ×30

A standard unbleached northern kraft pulp was used in all experiments. A 5-pound charge of pulp was allowed to soak overnight and then washed and beaten in the Dilts beater to a Schopper-Riegler freeness of 875 ml. Handsheets were made with a fiber furnish of 100% unbleached kraft pulp and with 50:50 mixtures of kraft and the various plastic pulps. The

Schopper-Riegler freeness of the mixtures varied from 840 to 880 ml. Because these handsheets were made without recirculation of white water, it was believed that substantial amounts of the plastic pulp would be lost through the 80-mesh wire, thereby causing a change

Table III. Refining and Screening of Plastic Pulp

Plastic pulp	*Accepted by 0.010-cut screen, %* *Unrefined*	*Refined*
Raw—undried	17.4	67.4
Raw—dried	9.3	77.0
Standard—undried	23.4	84.4
Standard—dried	19.4	85.1
Overcook—undried	87.9	100.0
Overcook—dried	85.1	97.0

in the composition of the handsheets as compared with the stock furnished to the sheet mold. The procedure was modified to compensate for this effect. Tests indicated that only a negligible amount of the kraft pulp was lost through the wire. A test sheet was then made with a known quantity of kraft pulp and of plastic pulp and the weight of the sheet determined. By assuming that all the loss was plastic pulp, a correction for the amount of plastic pulp required was calculated and this quantity was used in the preparation of the handsheets for testing. As a check on this procedure, fiber analyses were made on the resulting handsheets; these indicated the desired 50% composition. After forming, the wet sheets were placed between blotters and pressed at 25 p.s.i. to remove excess water and dried on a cylindrical drier at 275°F.

The results of the standard tests of these handsheets are shown in Table IV. From these results, it appears that a substantial decrease in tensile strength of the papers resulted from the substitution of plastic pulp for kraft pulp under the conditions used. A decrease in water absorbency also resulted, as indicated by the reduced rate of rise in a Klemm strip absorption test. However, subsequent observation indicated no change in absorbency for the alcoholic resin solutions. No significant change in porosity or apparent density was noted.

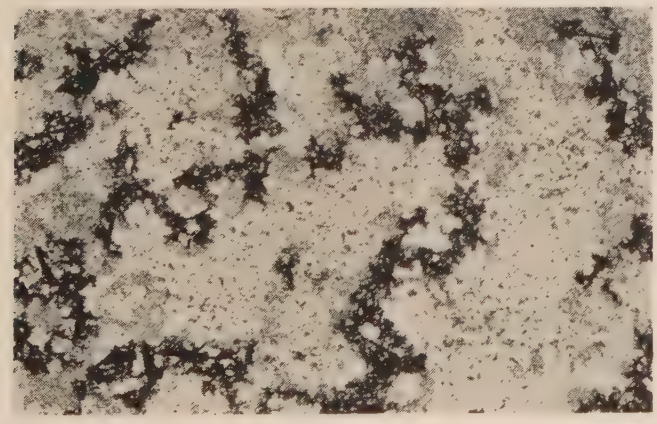

Fig. 3. Overcooked redwood plastic pulp, refined and screened (photographed dry). ×30

Handsheets of the various types were impregnated with a commercial alcohol-soluble phenolic laminating varnish (Bakelite BV-16526), using the standard Institute procedure (which consists of a dip-and-flow impregnation followed by drying to the required degree in an air circulating oven). The resin content was controlled by the variation of the solids content of the impregnating bath (using alcohol as the solvent). The volatile content was controlled by adjusting the time and temperature in the air circulating oven.

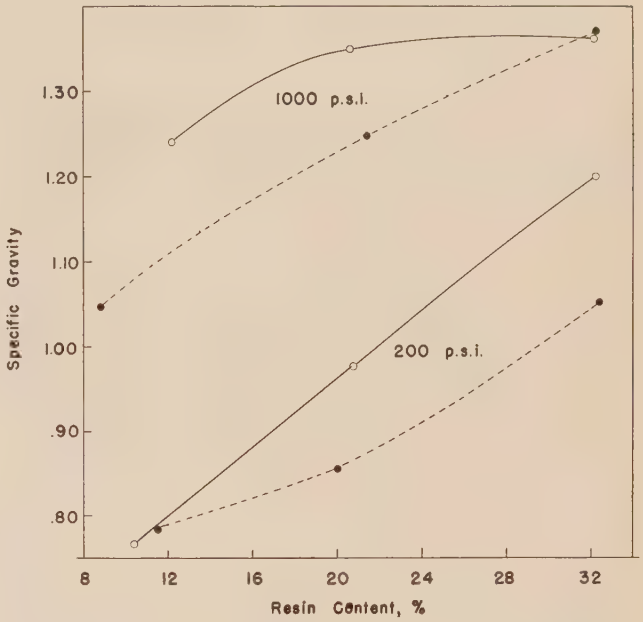

Fig. 4. The effect of resin content on specific gravity

●- - - -● All kraft pulp
○———○ 50:50 Kraft-plastic pulp

After impregnation, 20 sheets were combined and pressed in the laminating press for 20 minutes at 300°F. at pressures of either 200 or 1000 p.s.i. The finished laminates were then cut into samples and tested by standard A.S.T.M. procedures for specific gravity, tensile strength, flexural strength, modulus of elasticity, Charpy impact strength, Rockwell hardness, and water immersion. The results of these tests are given in Tables V and VI. The data in Table V, covering the substitution of standard dry plastic pulp for 50% of the kraft pulp, are plotted in Figs. 4, 5, 6, and 7 as a function of resin content at the two laminating pressures. By examination of these data, it is apparent that an improvement in bonding strength (as indicated by specific gravity, hardness, and water absorption) has been obtained at a given resin content by the substitution of the plastic pulp. However, this effect appears to be true only within certain ranges. At the

Table IV. Physical Properties of Handsheets Made with 100% Kraft Pulp and with 50:50 Kraft-Plastic Pulp

Plastic pulp	*Basis weight (24 × 36–500), lb.*	*Caliper, mils.*	*Apparent density*	*Schopper tensile, lb./in.*	*Gurley porosity, sec./100 cc.*	*Klemm strip absorption test, mm.* *5 min.*	*10 min.*
None	86.8	15.2	5.7	26.5	1	66	89
Raw—undried	84.5	17.1	4.9	18.9	0.6	5	11
Raw—dried	85.6	16.0	5.4	18.3	2	10	14
Standard—undried	86.7	17.4	5.0	17.4	0.8	8	13
Standard—dried	83.9	17.6	4.8	15.9	1	16	23
Overcook—undried	81.8	14.6	5.6	16.3	0.9	32	43
Overcook—dried	85.5	14.7	5.8	15.0	1	26	33

Table V. The Effect of Resin Content on Physical Properties of Laminates Made with Kraft Pulp and with Kraft-Plastic Pulp Mixture

Plastic pulp content	Resin content, %	Volatile content, %	Thickness, in.	Specific gravity	Tensile strength, p.s.i.	Modulus of elasticity, in tension p.s.i. × 10^6	Flexural strength, p.s.i.	Modulus of elasticity, in flexure, p.s.i. × 10^6	Edge-notched Charpy impact, ft.-lb./in.	Rockwell hardness	24-hr. water immersion Increase in weight, %	24-hr. water immersion Increase in thickness, %
Laminated at 200 p.s.i.												
None	11.5	3.2	0.155	0.785	7,900	0.68	7,200	0.60	1.55	M44	100	42
None	20.0	5.0	0.155	0.854	12,500	1.30	15,000	0.98	0.48	M49	53	15
None	32.4	6.3	0.148	1.052	16,900	1.68	22,600	1.61	0.47	M61	9.1	5.8
50% Std.—dried	10.4	4.8	0.146	0.768	5,500	0.51	5,400	0.53	1.06	M42	85	20
50% Std.—dried	20.8	5.7	0.132	0.978	10,900	1.16	13,700	1.15	0.44	M52	33	10
50% Std.—dried	32.2	6.0	0.131	1.201	15,200	1.50	19,300	1.40	0.48	M81	3.1	1.3
Laminated at 1000 p.s.i.												
None	8.8	3.2	0.113	1.049	15,500	1.66	18,500	1.30	0.93	M60	41	30
None	21.4	5.0	0.109	1.250	23,400	2.29	29,500	1.99	0.75	M85	4.7	3.8
None	32.0	6.3	0.117	1.368	24,700	2.16	30,000	1.85	0.70	M111	2.3	1.2
50% Std.—dried	12.2	5.0	0.099	1.241	17,200	1.51	23,200	1.57	0.57	M86	20	2.7
50% Std.—dried	20.6	5.7	0.100	1.350	17,100	1.47	26,200	1.70	0.64	M103	2.7	2.1
50% Std.—dried	31.9	6.0	0.116	1.362	19,100	1.59	22,900	1.75	0.57	M115	1.3	0.0

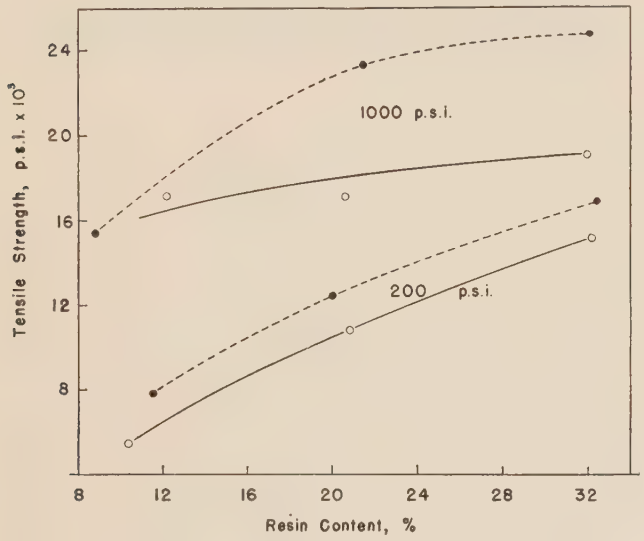

Fig. 5. The effect of resin content on tensile strength

●----● All kraft pulp
○————○ 50:50 Kraft-plastic pulp

low pressure and the low resin content (10%), no improvement in specific gravity was realized. At the high pressure and the high resin content, no improvement in specific gravity was noted. The latter effect is possibly caused by the fact that a "ceiling" in specific gravity is being approached and, consequently, there is no room for improvement. Additional data on higher resin contents would clarify this point. The former exception at low pressure and low resin contents may be caused by insufficient pressure and/or resin to utilize the flow properties of the plastic pulp itself. It is possible that, at resin contents lower than 10%, the plastic pulp sheets may actually have a specific gravity lower than that of the all-kraft sheets because of the greater springiness of the fibers and the absence of sufficient resin to bond the fibers together. The same general effects are noted with respect to the hardness of the laminates, except that it is necessary to use resin contents higher than 20% in order to obtain the increase in hardness at the low pressures. Again, the hardness appears to be approaching a maximum at the high pressure and high resin contents. This is also in line with the known behavior of laminates, in which hardnesses higher than 110 to 120 are seldom obtained with phenolic paper-base laminates. Water absorption is improved in all cases with the exception of the low resin content range at the high pressure. The tensile strength has been decreased as might be expected from the nature of the fibers involved. At the low pressure, the decrease is moderate, amounting to approximately 2000 p.s.i. at any resin content within the range studied. At the high pressure the tensile strength approaches its maximum at a somewhat lower resin content but the maximum obtainable is lowered by the substitution of plastic pulp. At 30% resin content, the all-kraft laminate has probably reached its maximum tensile strength at approximately 25,000 p.s.i. At the same resin content, the plastic pulp-kraft laminate has reached an apparent maximum of approximately 19,000 p.s.i.

In Table VI, the data for the laminates made with various pulps at resin contents of approximately 20% have been arranged in two groups, corresponding to the two laminating pressures used. In general, the effect of substituting other types of plastic pulp is less than would have been expected on the basis of previous experience. With respect to specific gravity, the dry pulps all appear to be better than kraft, with the raw, standard, and overcooked pulps falling in that order of increasing effect upon density. The undried pulps are less consistent, showing an apparent low value for the standard pulp. At the high pressure the

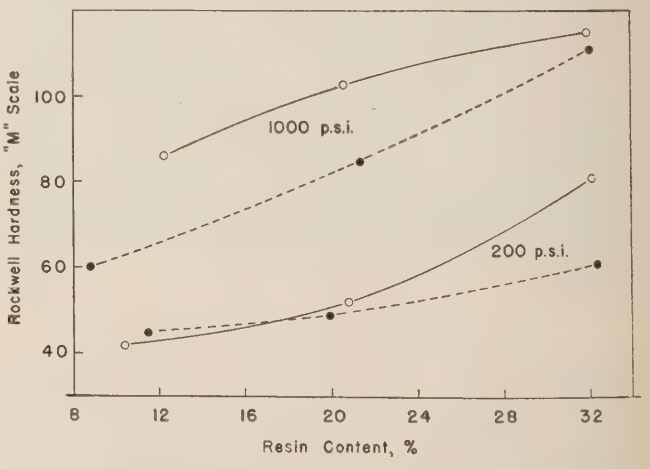

Fig. 6. The effect of resin content on Rockwell hardness

●----● All kraft pulp
○————○ 50:50 Kraft-plastic pulp

Table VI. The Effect of Type of Plastic Pulp on Physical Properties of Laminates Made with 50:50 Kraft-Plastic Pulp at 20% Resin Content

Plastic pulp content	Resin content, %	Volatile content, %	Thickness, in.	Specific gravity	Tensile strength, p.s.i.	Modulus of elasticity, in tension, p.s.i. × 10^6	Flexural strength, p.s.i.	Modulus of elasticity, in flexure, p.s.i. × 10^6	Edge-notched Charpy impact, ft.-lb./in.	Rockwell hardness	24-hr. water immersion: Increase in weight, %	24-hr. water immersion: Increase in thickness, %
Laminated at 200 p.s.i.												
None	20.0	5.0	0.155	0.854	12,500	1.30	15,000	0.98	0.48	M49	53	15
Raw—undried	22.2	5.0	0.139	0.956	11,100	1.19	13,900	1.05	0.49	M52	39	10
Raw—dried	19.6	5.7	0.134	0.940	9,600	1.45	12,500	0.89	0.46	M47	41	13
Std.—undried	22.1	5.0	0.148	0.873	9,100	0.97	11,600	0.89	0.47	M47	51	13
Std.—dried	20.8	5.7	0.132	0.978	10,900	1.16	13,700	1.15	0.44	M52	33	10
Overcook—undried	18.7	5.0	0.126	1.048	12,000	1.37	15,000	1.10	0.49	M54	30	9.2
Overcook—dried	19.1	4.9	0.127	0.999	9,500	1.30	13,000	1.10	0.45	M48	32	9.8
Laminated at 1000 p.s.i.												
None	21.4	5.0	0.109	1.250	23,400	2.29	29,500	1.99	0.75	M85	4.7	3.8
Raw—undried	23.7	5.0	0.098	1.441	20,400	1.78	26,600	1.80	0.64	M109	2.4	1.6
Raw—dried	21.7	5.7	0.105	1.278	19,300	1.79	26,100	1.79	0.68	M108	3.6	2.0
Std.—undried	18.5	5.0	0.099	1.275	18,900	1.64	24,400	1.72	0.63	M91	6.4	4.1
Std.—dried	20.6	5.7	0.100	1.350	17,200	1.47	26,200	1.70	0.64	M103	2.7	2.1
Overcook—undried	19.8	5.0	0.105	1.229	18,100	1.70	25,100	1.75	0.65	M99	3.4	2.1
Overcook—dried	21.2	4.9	0.094	1.362	18,300	2.65	24,400	1.88	0.54	M111	2.6	1.8

dried pulps fall in the same order as at the low pressure with the greatest effect being noticed in going from raw to standard pulp. Undried pulps are in the reverse order for no apparent reason.

There is a question whether the differences noted in the tensile strength of the low-pressure laminates are significant. Of the dried pulps, the standard exhibited the best strength and, of the undried pulps, it had the lowest strength. The laminate from the undried, overcooked pulp showed a tensile strength approximately equal to that of the 100% kraft laminate. For the high-pressure laminates, the strength of the dried standard pulp is lowest of all the laminates containing plastic pulp. There seems to be a tendency for the laminate from the raw pulp to have somewhat better strength than those from the other pulps but the differences are not great; all pulps, however, yield laminates with strengths lower than that of the kraft laminate. The effects for flexural strength correlate quite well with those for tensile strength.

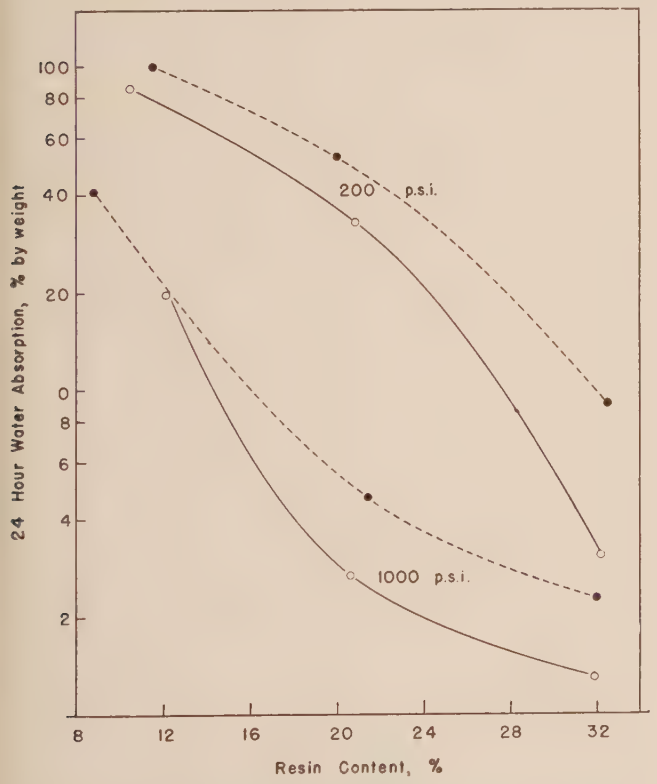

Fig. 7. The effect of resin content on water absorption
●----● All kraft pulp
○——○ 50:50 Kraft-plastic pulp

Of the low-pressure laminates, prepared from dried pulps those from the standard and overcooked pulps exhibit better performance as regards water absorption than does that from the raw pulp but, of the undried pulps, the standard cook is no better than the kraft and the raw and overcooked pulps are approximately the same as the corresponding dried pulp. In the case of the high-pressure laminates, those prepared from the standard and overcooked dried pulps appear to be somewhat better than that from the raw pulp and again that from the standard undried pulp is less satisfactory than the all-kraft laminate.

SUMMARY

The substitution of low-cost redwood plastic pulp for part of the kraft pulp phenolic resin saturating paper permitted the attainment of a given degree of density, hardness, and water absorption at a somewhat lower resin content. This effect was accompanied by a decrease in the strength of the handsheets (and presumably of machine-made papers) and in the tensile and flexural strength of the laminates. The differences between dried and undried pulps were not great and it appears probable that the drying at the time of forming the handsheets was of the same order in its effect on the pulp as drying during the manufacture of the pulp itself. In general, the dried pulps gave more consistent results than did the undried pulps, with results which agreed with the known changes in flow properties of the pulps with different degrees of cooking. Additional tests would be required to determine the value of the substitution of any one of these pulps in any specific application.

Received Feb. 5, 1951. Presented at the Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 19–22, 1951.

Fermentation to Ethanol of Concentrated Calcium, Magnesium, and Ammonium Sulphite Waste Liquors

Sulphite Waste Liquor I

HILDA DANIELS AGAR and JOSEPH L. McCARTHY

Exhaustively steam-stripped calcium, magnesium, and ammonium sulphite waste liquors have been fermented by yeast to yield ethanol and carbon dioxide. Fermentation was carried out at various known conditions of total solids concentration and of degree of acidity. Yields of ethanol per unit weight of fermentable sugar present were found to remain approximately constant throughout the range of conditions studied. Rates of fermentation decreased as total solids concentration increased but were not markedly influenced by hydrogen-ion concentration between pH 4 and pH 6.

THE fermentation to ethanol of sugars in sulphite waste liquor is of interest because by this means there may result a very substantial reduction in biochemical oxygen demand of the liquor together with production of a commodity of extensive and diversified utility in industry.

Since fermentation of the usual unconcentrated liquor gives rise to ethanol at concentrations of only about 6 or 8 grams per liter, the rectification of such dilute solutions requires considerable heat and the cost of the necessary steam is one of the major expenses incurred in industrial alcohol production from sulphite waste liquor.

However, if *concentrated* sulphite waste liquors were available and could be fermented satisfactorily, less heat and thus less expense would be necessary for rectification per unit ethanol produced, and the total production costs might be substantially lowered. A 40% reduction in cost was estimated in 1918 by Oman (*20*) for fermentation of calcium-sulphite waste liquors concentrated fivefold by removal of water as ice. Although concentration of sulphite waste liquor is at present unusual, its evaporation is being practiced in some Scandinavian plants (*3*) and is also of interest in the United States in connection with the magnesium sulphite waste liquor recovery system (*14*, *15*, *25*) as well as other processes. If concentration is justified in one or more of these processes, then concentrated sulphite waste liquors may become available with the result that the economies of industrial alcohol production may become shifted by changes in steam requirements provided that the concentrated liquor can be fermented satisfactorily.

The question of the fermentability of concentrated sulphite waste liquor sugars in the presence of the high concentration of possibly toxic nonsugar components was raised by Foth (*5*) about the time of World War I. More recently, Bergson (*1*), Sandberg, Nilsson, and Blomquist (*21*), and Buevskoi (*2*) have concerned themselves with fermentation of concentrated sulphite waste liquor, and Buevskoi recommended that the liquor be neutralized with calcium oxide, evaporated to 40 or 50% of its original volume, and then fermented at about 5% sugar content to give alcohol in sulphite waste liquor at a concentration of about 2%. Two other papers have appeared since our investigation was completed. Thus Enebo, Johnsson, and Lundin (*4*) conducted semicontinuous fermentation experiments with concentrated dissolving pulp liquors and also paper pulp liquors and reported that "normal fermentation" of paper pulp liquor proceeded up to concentrations of 75 or 90 grams of reducing substances per liter; yeast growth appeared usual and alcohol yields remained constant throughout the range of about 30 to 90 grams of reducing substances per liter. Tomlinson (*26*) has described in a patent the fermentation of magnesium sulphite waste liquor containing solids at concentrations to above 20%.

The present research was conducted to provide a systematic description of the results of fermentation of calcium, magnesium, and ammonium-sulphite waste liquors under controlled conditions of total solids concentration, degree of acidity, and inoculum.

Our approach has been based on Slator's studies (*22*, *23*) of the kinetics of alcoholic fermentation by yeast which showed that the fermentation velocity of pure glucose was independent of concentration within the limits of 1 to 10%. However, the fermentation velocity decreased as the sugar concentration was decreased below 0.5% or increased above 10%. Experiments with aqueous solutions of pure glucose in these Laboratories have confirmed these observations. Therefore, if all sulphite waste liquor sugars behave like glucose, then when a sulphite waste liquor originally containing 12% total solids and 2% fermentable sugars is evaporated to one fifth its original volume, this concentrated liquor should ferment at the same rate as the original liquor provided the same weight ratio of yeast to fermentable sugar exists in the systems. An observed decrease in fermentation rate could then presumably be interpreted as a manifestation of the toxicity of substances concentrated along with the sugars.

Sulphite waste liquor contains sulphur dioxide and some of its derivatives which retard alcoholic fermentation (*6*, *16*). Hagglund and co-workers (*7*, *8*, *9*, *10*, *11*, *12*) have considered this problem and recommended that dissolving pulp or fodder cellulose sul-

HILDA DANIELS AGAR, present address: Department of Microbiology, University of Washington, Seattle 5, Wash.
JOSEPH L. MCCARTHY, Member TAPPI: In Charge, Chemical Engineering Division, Pulp Mills Research, Department of Chemistry and Chemical Engineering, University of Washington, Seattle 5, Wash.

phite waste liquor should be fermented at pH 4.5 to 5.0, while liquor recovered after less intense processing conditions should be fermented at pH 6 or above. The differences between the recommended acidity conditions probably arise from differences existing in the concentrations of loosely combined sulphur dioxide present in the sulphite waste liquors arising from the two types of pulping operations. In earlier work in these Laboratories, it has been shown that the "free" and much of the "loosely combined" sulphur dioxide can be removed from calcium sulphite waste liquor by steam stripping (*18*). Liquors steam stripped to various degrees have been found to ferment at rates which decrease with increase in concentration of "loosely combined" sulphur dioxide and of hydrogen ion; exhaustively steam-stripped calcium sulphite waste liquors fermented at a rate which approached that of pure glucose solutions. On these grounds, it was of interest in the present study to prepare all sulphite waste liquors by exhaustive steam stripping and then to ascertain the influence of the acidity and of the total solids concentration at which the fermentations were carried out.

EXPERIMENTAL

Preparation of Samples for Fermentation

Samples of paper pulp and also dissolving pulp calcium sulphite waste liquors were kindly provided from commercial sources using mostly western hemlock wood (*Tsuga hetrophylla*) and a little white fir (*Abies grandis*). Magnesium and ammonium sulphite waste liquors were prepared in the laboratory from western hemlock wood. The liquors were exhaustively steam stripped at atmospheric pressure.

The stripped ammonium sulphite waste liquor at pH 4.0 was concentrated under vacuum at 40 to 50°C. to a thick syrup and, just before fermentation, samples were prepared at pH 5.0 and pH 6.0 by appropriate addition of concentrated ammonium hydroxide. Calcium and magnesium sulphite waste liquors, after stripping, were first neutralized with a slurry of the appropriate base to yield the desired acidity levels, then concentrated under vacuum to thick syrups which were later diluted as desired. The dissolving pulp calcium sulphite waste liquor, which had been diluted in the blow pit to about 4% total solids and could be brought to only pH 2.2 by exhaustive steam stripping, was neutralized in aliquots to pH 3, 4, 5, and 6 and each aliquot was then concentrated under vacuum to about 60% total solids; considerable calcium sulphate crystallized out during evaporation which indicated that the presence of unusually large amounts of sulphuric acid limited the reduction in acidity which could be brought about in this case by steam stripping.

The total solids content of the concentrated liquors was determined by drying diluted aliquots of the liquor on quartz particles in weighing bottles in a vacuum oven at about 20 mm. Hg pressure at 60°C. for 24 hours. Specific gravities were determined by the pycnometer method. The analytical values thus obtained were used in calculating the concentrations of total solids in the rediluted liquors.

Fermentation of Concentrated Sulphite Waste Liquors

Fermentations were conducted in all-glass fermentometers (Fig. 1) of the constant pressure type which had been previously standardized with unconcentrated sulphite waste liquor for the study of fermentation rates and fermentable sugar concentrations. The instruments, designed by E. J. Ordal of the Department of Microbiology, University of Washington, consist of two 125-ml. Florence flasks equipped with a single side arm placed in a position perpendicular to the motion of shaking. The two flasks are connected by means of ground-glass joints to a manometer filled to a definite level with Brodiés solution (*27*). A mercury reservoir, consisting of a 25-ml. graduated pipet equipped with a leveling bulb, was connected to the right arm of the manometer thus permitting the direct collection and measurement of the gas (up to 25 ml.) produced by fermentation. The manometers were mounted on wood supporting racks which could be readily attached to a motor-driven shaking device (112 strokes per minute) with the flasks completely immersed in a 30° ± 0.05°C. water bath. Six of these manometers were used simultaneously.

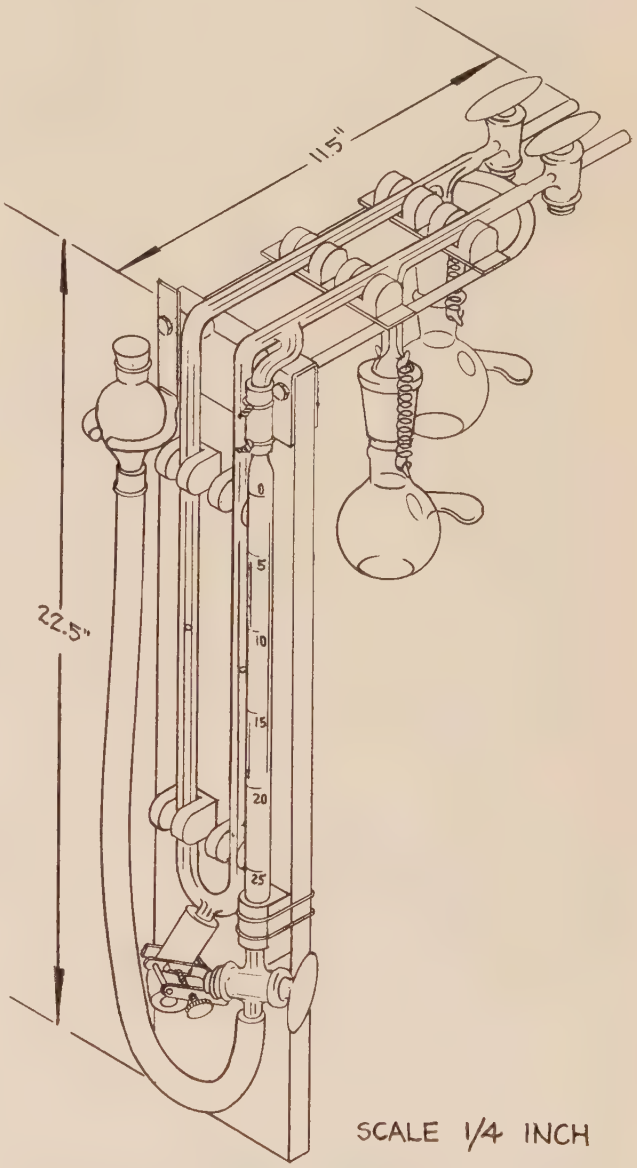

Fig. 1. Apparatus used for fermentation of sugars in sulphite waste liquors

Table I. Fermentation of Calcium Sulphite Waste Liquors at Various Acidity and Concentration Levels

Sample	Fermentation conditions: pH	Total solids concentration, g./l.	Fermentation rate, (k_0), ml./min.	Initial fermentable sugar concentration, g./l.	Final ethanol concentration, g./l.	Fermentation efficiency, moles/mole
Paper pulp	6.0	142	0.69	21	7.9	1.5
Paper pulp	6.0	195	0.67	30	10.8	1.4
Paper pulp	6.0	272	0.60	42	...	...
Paper pulp	6.0	422	0.52	64	22.7	1.4
Paper pulp	6.0	570	0.38	88	32.9	1.5
Paper pulp	5.0	131	0.63	21	7.6	1.4
Paper pulp	5.0	239	0.60	37	12.8	1.4
Paper pulp	5.0	297	0.54	46	16.4	1.4
Paper pulp	5.0	412	0.51	65	22.4	1.4
Paper pulp	5.0	542	0.38	88	...	...
Paper pulp	4.5	167	0.64	28	9.8	1.4
Paper pulp	4.5	251	0.60	41	14.2	1.4
Paper pulp	4.5	347	0.52	59	20.4	1.4
Paper pulp	4.5	436	0.47	75	25.9	1.4
Paper pulp	4.5	590	0.33	98	37.3	1.5
Dissolving pulp	6.4	104	0.66	22	7.8	1.4
Dissolving pulp	6.4	154	0.65	33	...	...
Dissolving pulp	6.4	228	0.64	49	17.5	1.4
Dissolving pulp	6.4	325	0.56	72	24.7	1.3
Dissolving pulp	6.4	425	0.45	95	33.5	1.4
Dissolving pulp	5.0	110	0.66	23	8.2	1.4
Dissolving pulp	5.0	162	0.63	35	12.6	1.4
Dissolving pulp	5.0	225	0.58	50	17.9	1.4
Dissolving pulp	5.0	292	0.54	65	23.6	1.4
Dissolving pulp	5.0	421	0.44	95	33.9	1.4
Dissolving pulp	4.0	107	0.64	23	8.2	1.4
Dissolving pulp	4.0	153	0.65	34	12.1	1.4
Dissolving pulp	4.0	228	0.59	51	18.8	1.4
Dissolving pulp	4.0	291	0.55	66	24.5	1.5
Dissolving pulp	4.0	425	0.42	97	35.7	1.4
Dissolving pulp	3.0	100	0.58	22	8.3	1.5
Dissolving pulp	3.0	150	0.52	33	12.1	1.4
Dissolving pulp	3.0	224	0.47	50	18.6	1.5
Dissolving pulp	3.0	285	0.41	64	23.9	1.5
Dissolving pulp	3.0	399	0.32	89	34.1	1.5
Dissolving pulp	2.2	99	0.39	23	8.3	1.4
Dissolving pulp	2.2	150	0.33	34	12.4	1.4
Dissolving pulp	2.2	222	0.26	52	18.8	1.4
Dissolving pulp	2.2	284	0.23	70	25.1	1.4
Dissolving pulp	2.2	410	0.20	111	37.5	1.3

The procedure followed consisted of accurately weighing a small volume of the concentrated liquor at a known hydrogen ion concentration into the main compartment of each of the front flasks attached to the right-hand side of the manometers. Water in graded amounts was then added to each of the five flasks thus providing samples for fermentation at known acidity and total solids concentration. The sixth manometer in each experiment was used as a fermentation control and contained 5 ml. of a standard, freshly prepared, 2% glucose solution in the main compartment of the cup. One milliliter of a 60% suspension of baker's yeast (*Saccharomyces cerevesiae*) prepared by suspending 15 grams of pressed commercial baker's yeast (Fleischman's baker's yeast obtained from Standard Brands, Inc., Seattle, Wash. was used but not the small compressed "yeast cakes" since they frequently contain added fillers and vitamins) in 10 ml. of distilled water was transferred to the side arm of each fermentation flask by means of a hypodermic syringe and an appropriately bent needle. The second flask, attached to the left-hand side of each manometer, contained 0.5 ml. of distilled water to equalize the vapor pressure on both sides of the manometer. The flasks were securely attached to the manometer and were held in place by small wire springs.

The fermentations were conducted in an atmosphere of pure nitrogen attained by alternately evacuating the flasks and manometers to 75 mm. Hg. pressure and refilling them with nitrogen purified by passage through a tube containing heated reduced copper to remove residual oxygen. The flasks were alternately evacuated and refilled with nitrogen five times with continuous shaking in the constant temperature bath to assure the complete removal of air. The flasks were then shaken for an additional 5 minutes to permit attainment of equilibrium conditions of temperature and pressure as evidenced by the maintenance of a constant level of the Brodiés solution in both sides of the manometer.

When equilibrium had been established the flasks and manometer were removed from the water bath, and the yeast suspension in the side arm well mixed with the substrate in the cup proper by tipping the manometer backward and forward several times. The six manometers were "dumped" in this manner consecutively at half-minute intervals. Shaking was then resumed and the apparent volume of carbon dioxide evolved was measured at 5-minute intervals, the time of fermentation being measured from the instant of

mixing the yeast and substrate. Fermentation was continued until no change in the measured carbon dioxide volume was observed over a period of four consecutive 5-minute intervals. Endogenous fermentation controls containing distilled water or buffer solution in place of a fermentable substrate were run at frequent intervals under identical fermentation conditions; negligible amounts of carbon dioxide (0.0 to 0.2 ml.) always resulted.

From the data obtained, plots of the volumes of carbon dioxide collected against time of fermentation were prepared. Because the curves thus obtained from the fermentation of pure glucose and also well-stripped sulphite waste liquors indicated progress of a process of zero order with respect to sugar concentration throughout the greater portion of the fermentation, fermentation rates were expressed numerically as the number of milliliters of carbon dioxide evolved (at 0°C. and 760 mm. Hg pressure) per minute, or k_0, the slope of the straight-line portion of the curve. Fermentation rates thus calculated for the sulphite waste liquors studied are presented in Tables I and II.

Table II. Fermentation of Ammonium and Magnesium Sulphite Waste Liquors at Various Acidity and Concentration Levels

Sample	Fermentation conditions: pH	Total solids concentration, g./l.	Fermentation rate, (k_0), ml./min.	Initial fermentable sugar concentration, g./l.	Final ethanol concentration, g./l.	Fermentation efficiency moles/mole
NH_4 SWL	6.0	149	0.74	25	8.9	1.4
NH_4 SWL	6.0	201	0.68	36	12.9	1.4
NH_4 SWL	6.0	275	0.58	51	17.3	1.3
NH_4 SWL	6.0	360	0.49	65	22.2	1.3
NH_4 SWL	6.0	501	0.36	93	30.5	1.3
NH_4 SWL	5.0	136	0.71	25	8.9	1.4
NH_4 SWL	5.0	202	0.66	37	13.0	1.4
NH_4 SWL	5.0	265	0.55	48	17.1	1.4
NH_4 SWL	5.0	375	0.44	69	23.9	1.4
NH_4 SWL	5.0	468	0.34	85	28.7	1.3
NH_4 SWL	4.0	140	0.64	26	9.0	1.4
NH_4 SWL	4.0	207	0.57	39	13.2	1.3
NH_4 SWL	4.0	315	0.44	59	19.8	1.3
NH_4 SWL	4.0	359	0.38	69	23.6	1.3
NH_4 SWL	4.0	491	0.30	91	31.6	1.4
Mg SWL	6.0	165	0.70	22	8.0	1.4
Mg SWL	6.0	234	0.65	31	11.4	1.4
Mg SWL	6.0	330	0.60	46	...	...
Mg SWL	6.0	422	0.51	57	16.6	1.4
Mg SWL	6.0	572	0.37	80	27.8	1.4
Mg SWL	5.1	159	0.69	22	8.0	1.4
Mg SWL	5.1	279	0.68	31	11.0	1.4
Mg SWL	5.1	326	0.59	46	16.3	1.4
Mg SWL	5.1	405	0.51	58	20.2	1.4
Mg SWL	5.1	545	0.37	78	27.6	1.4
Mg SWL	4.3	203	0.65	28	9.6	1.3
Mg SWL	4.3	241	0.61	33	11.6	1.4
Mg SWL	4.3	341	0.55	49	17.4	1.4
Mg SWL	4.3	429	0.48	62	22.6	1.4
Mg SWL	4.3	588	0.33	84	29.7	1.4

Determination of Alcohol Yields

On completion of the fermentations, the fermented liquors were analyzed for alcohol content by a semi-micro dichromate oxidation method. The fermented samples were quantitatively transferred to an all-glass micro-distillation apparatus, neutralized to pH 7.0 to 7.5 with barium oxide, and carefully distilled almost to dryness. The distillates were collected in an iced receiver and diluted to exactly 25 ml. One-milliliter aliquots containing 1 to 2 mg. of ethanol, were oxidized with 2 ml. of 0.1 *N* potassium dichromate in 25% sulphuric acid by heating on a steam bath in a sealed flask for 20 minutes. After cooling, the dichromate remaining was determined with potassium iodide and 0.0100 *N* sodium thiosulphate solution. The method was standardized against known samples prepared from absolute ethanol, and suitable controls showed that the direct distillation of fermented samples without previous removal of the yeast did not yield high results. Ethanol determinations on unfermented samples of the various sulphite waste liquors studies also showed that there were no dichromate reducing substances present in the distillates of the original liquors which might substantially interfere with the results. Yields expressed in grams of ethanol per liter of the fermented liquor were calculated and the results are recorded in Tables I and II.

Fermentation Efficiency

The fermentation efficiencies (Tables I and II) have been defined as the number of moles of ethanol produced per mole of fermentable sugars present in the liquor. The ethanol yield was determined by actual analysis and the fermentable sugar content of the liquor was calculated as glucose from the total volume of carbon dioxide liberated. The data were suitably corrected for carbon dioxide dissolved in the aqueous phase (*27*) and for assimilation of a part of the fermentable sugars by the yeast during rapid fermentation (*28, 29*). The correction factor for fermentative assimilation, 0.79, was established empirically by fermentation of pure glucose under the conditions of fermentation employed.

Prior studies have shown that sulphite waste liquor contains mannose and fructose in addition to glucose (*13, 17, 24*), and in these Laboratories a Pacific Northwest calcium sulphite waste liquor has recently been examined by chromatographic and other procedures (*19*) with the result that the total sugars present were estimated to be distributed as follows: mannose, 48%; glucose, 15%; xylose, 15%; galactose, 10%; arabinose, 6%; fructose, less than 2%; and unaccounted for, 4%. Although the rates of fermentation of mannose and fructose differ somewhat from the rate of fermentation of glucose, these sugars yield almost identical amounts of carbon dioxide and are included in the category of "fermentable sugar." Galactose and pentoses present in the liquor would not be included since they are not fermented by the yeast employed.

DISCUSSION

The experiments seem to show that exhaustively stripped sulphite waste liquors can be fermented at up to 50 or 60% total solids concentration without adversely affecting the fermentation efficiency, i.e., the yield of ethanol per unit fermentable sugar consumed. Variations of fermentation efficiency evident in Tables I and II can probably be attributed to experimental error.

However, with all types of sulphite waste liquor studied, the rates of fermentation decreased as the total solids concentration was increased (Figs. 2 and 3). For the calcium and magnesium liquors, the rate at 40 to 50% total solids concentration was about two thirds of that at 10% concentration while for the ammonium liquor the rate decreased to about one half. These trends indicate that lignin sulphonates or other nonsugar constituents of sulphite waste liquors do retard fermentation and to a degree which increases with increase in concentration of these components.

Hydrogen ion concentrations between pH 4 and pH 6 did not influence greatly the fermentation rates for calcium paper pulp or magnesium sulphite waste liquors although slightly higher rates were observed at lower acidity under the conditions of fermentation employed. For the calcium dissolving pulp or the ammonium sulphite waste liquors, the rates of fermentation became considerably slower as the acidity of the liquors was increased.

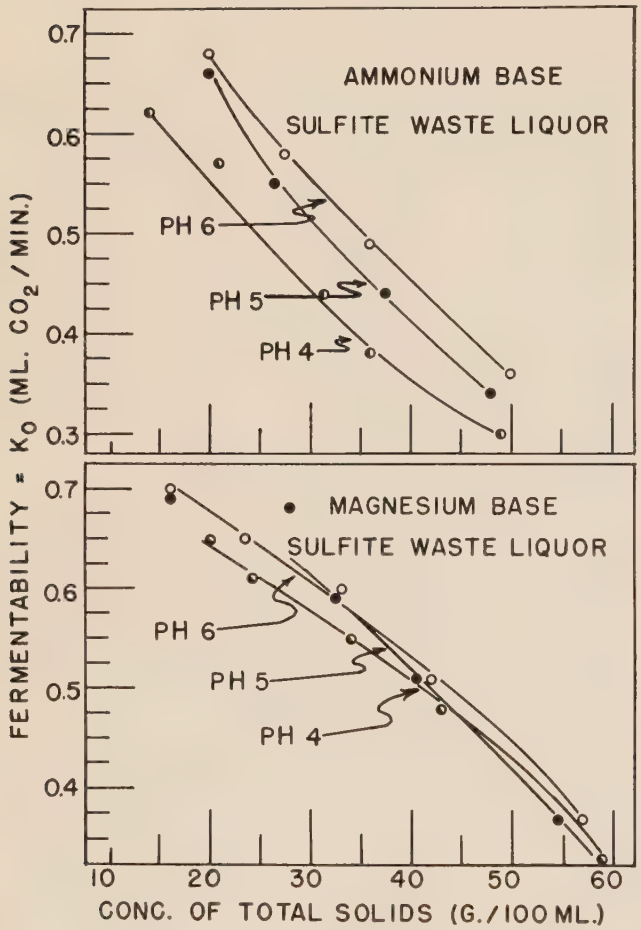

Fig. 2. Rates of fermentation of sugars at various conditions of acidity and concentration in paper pulp and dissolving pulp calcium sulphite waste liquors

Comparison of the fermentation rates of the several liquors at the same conditions of acidity and total solids concentration indicates that the calcium paper pulp and the magnesium sulphite waste liquor fermented at about the same rates while the calcium dissolving pulp and the ammonium sulphite waste liquors fermented more slowly. However, the differences found between the rates of fermentation of calcium sulphite waste liquors from paper pulp vs. dissolving pulp production indicate that fermentability differences should probably be attributed to influences of processing conditions rather than influences of cations employed in pulping.

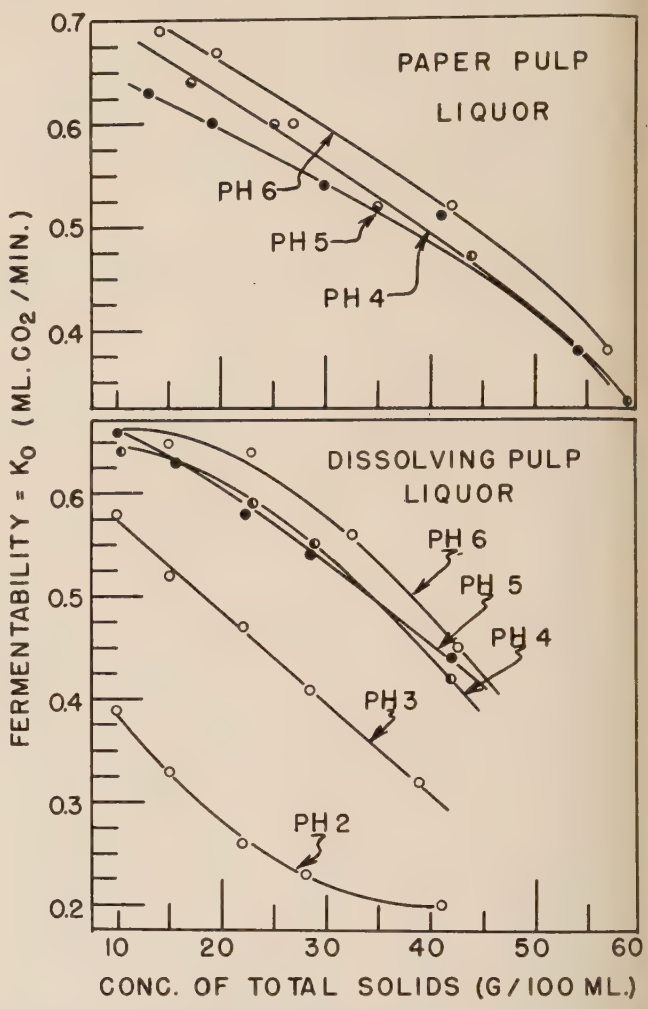

Fig. 3. Rates of fermentation of sugars at various conditions of acidity and concentration in ammonium and magnesium sulphite waste liquors

In general, the present work suggests that satisfactory alcoholic fermentation of sulphite waste liquors can be carried out up to 20 or 30% total solids concentration. Ethanol yields should not be markedly affected although fermentation at a given yeast-sugar ratio would proceed at a somewhat lower rate. Thus, if concentrated sulphite waste liquors become available, it appears that these might be used in part for industrial alcohol production with considerable savings in rectification steam and perhaps in equipment cost as compared with requirements for processing sulphite waste liquors at blowpit concentrations.

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Received Nov. 27, 1950. Presented before the Fermentation Division at the 114th Meeting of the American Chemical Society in Portland, Ore., Sept. 13–17, 1948.

The authors appreciate the helpful suggestions of Q. P. Peniston and A. E. Markham and the analytical assistance of V. F. Felicetta.

Continuous Laboratory Propagation of Sulphite Waste Liquor Yeast

Sulphite Waste Liquor II

AARON E. MARKHAM, HILDA D. AGAR, and JOSEPH L. McCARTHY

***Torulopsis utilis* yeast has been grown on steam-stripped, calcium sulphite waste liquor in continuous flow equipment of laboratory scale. Operating conditions used in preliminary experiments are reported along with resultant sugar conversions, B.O.D. and other properties of effluents, and yields and some characteristics of the yeasts produced. Data are correlated by regarding yeast propagation as a second-order process and equations are suggested which may be useful in preliminary calculations for design of yeast plant equipment.**

Partial utilization of sulphite waste liquor, arising as a by-product from sulphite wood pulp production, has been carried out in some European plants during World War II by conversion of its sugars into yeast which served as a food for animals and man (*1*). This conversion of dissolved sugars to suspended yeast cells, which can then be fairly readily removed mechanically by filtration or centrifugation, brings about marked reduction of the biological oxygen demand of sulphite waste liquor, and, at the same time, provides a product which may be offered in commerce as a feed valuable especially for the proteins and vitamins which it contains. In view of these features of yeast production, and because at the time the present investigation was undertaken not much information was available with respect to processing sulphite waste liquors arising from Pacific Northwest softwoods, this experimental study was initiated in order to confirm operating conditions necessary for satisfactory yeast propagation in continuous laboratory-scale equipment, to roughly measure yields and some characteristics of the yeast produced, and to produce yeast in sufficient quantity to permit preliminary animal and poultry feeding tests to be carried out. After some preliminary work, circumstances changed and a full study could not be completed. However, since a few careful continuous propagation experiments along with some yeast evaluations had been carried out, it seemed worth while to record this description of the work.

Aaron E. Markham, Research Chemical Engineer; Hilda D. Agar, Assistant Bacteriologist, present address, Dept. of Microbiology, University of Washington; and Joseph L. McCarthy, Member TAPPI, in Charge, Chemical Engineering Division, Pulp Mills Research, Department of Chemistry and Chemical Engineering, University of Washington, Seattle, Wash.

EXPERIMENTAL

Calcium sulphite waste liquor, steam stripped (*2, 3*) at the mill and shipped to this laboratory in 30-gallon wood barrels was kindly provided by the Puget Sound Pulp and Timber Co. of Bellingham, Wash., through the courtesy of E. O. Ericsson, Technical Director. The wood used in preparation of these liquors was about 85% hemlock and 15% white fir.

Process Flow Sheet (See Fig. 1)

Sulphite waste liquor, as received, was stored in an 1100-liter wood stave tank. It was withdrawn from storage and pumped to the propagator at the desired constant rate by a Zenith stainless steel metering gear pump. In some experiments the liquor was pasteurized by pumping it through a 20-liter stainless steel tank, maintained by indirect steam heat at 105 to 110°C., then cooled to room temperature in a heat exchanger, and fed directly into the propagator. The

spent liquor, containing the suspended yeast, left the propagator as foam and flowed slowly into the centrifuge which was equipped with an imperforate stainless steel basket spinning continuously at 1800 r.p.m. The spent centrifuged liquor overflowed to the sewer. The yeast collected in the centrifuge basket was removed periodically, washed by resuspending it in water and recentrifuging, and dried in a vacuum or tunnel drier. It was then ground in a Koerner laboratory grinder and stored for later use in analysis and feeding experiments.

The Yeast Propagator

The propagator was a Douglas-fir wood pipe (12 feet long by 12 inches I.D.) closed at the bottom and supported in a vertical position. Liquor was fed to the propagator at a point 4 feet below the top and was discharged as foam overflowing from the top.

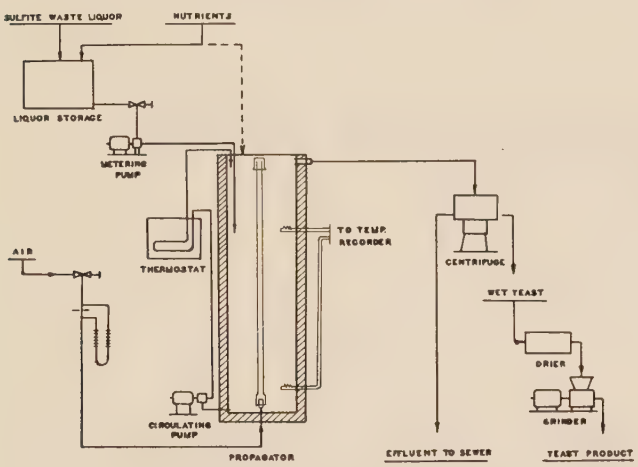

Fig. 1. Flow sheet of continuous yeast propagation plant

It was desired to operate with nearly complete mixing in the propagator. In initial experiments, this was attempted by use of an air lift but the results were not wholly satisfactory. In later experiments here reported, liquor was held at the desired temperature and also mixed by external circulation, i.e., it was pumped from the bottom of the propagator, through a stainless steel heat exchange tube coil situated in a water bath maintained at an appropriate temperature, and then back into the top of the propagator tower. Air was fed into the propagator at the bottom through a dispersion device. Several air dispersion arrangements were tried seeking the best foam at lowest air rate and pressure drop, and the one finally used consisted of a 1-inch diameter stainless steel circular disk perforated with about 150 holes of about 0.01 inch diameter and mounted horizontally on the end of a vertical air inlet line.

Additional control of propagator liquor temperature was obtained by a $^1/_4$-inch stainless steel heat exchanger tube 5 feet long installed as a coil situated near the bottom of the propagator. Heating or cooling water was circulated through this coil as necessary.

Two Plexiglas windows, one above the other on the side wall near the bottom of the propagator, gave access to the interior and permitted visual observation of the liquid level and foam formation.

Operating Controls and Analytical Procedures

The temperature of the liquor in the propagator was measured by two thermometers inserted through the side wall at distances from the bottom of 1 and 8 feet, respectively. A Micromax recorder served to provide a continuous record of these temperatures, as well as that of the heat exchanger bath through which the liquid was recirculated. Propagator liquor temperature was held at about 30°C.

The sulphite waste liquor feed rate was controlled quite accurately by the metering pump, varying only with minor changes in the speed of the motor. The flow rate was checked frequently against the observed changes in the level of the feed tank, which was calibrated, and was always found to be in good agreement. The volume of sulphite waste liquor fed was calculated from the time and the measured flow rates.

The liquid level in the propagator was observed through the Plexiglas windows, when it was within their range, as was usually the case. Otherwise it was estimated from the liquid head in the propagator, observed in a transparent plastic sight tube gage.

The foam density was determined periodically by withdrawing a sample just above the liquid level, and observing the volume of liquid which resulted from the settling of the foam. While the sample was being withdrawn, considerable liquid always separated, which was not included in the calculation of the density. The density of the foam in the propagator was thus usually considerably greater than the average value of 0.19 gram per milliliter observed by the above method.

To determine yeast yields, samples of the liquor leaving the propagator were centrifuged in small calibrated tubes and the observed volume of sedimented yeast converted to weight per cent from calibration curves; from such estimations of yeast concentration and from measurement of the cumulative volume of effluent, the yield of yeast was calculated. As a check on this determination, the total yeast product over a known time period was removed and its weight and moisture content determined; this yield value was always somewhat too low because of substantial losses incurred during washing and removal from the centrifuge.

The sulphite waste liquor was analyzed regularly for content of total solids, ash, nitrogen, reducing substances, and methoxyl, by methods described previously (*4*). Nitrogen and ash in the yeast were determined by the same procedures. Sulphate was determined by a conductometric method (*5*). Arsenic analyses were made by Edward Krupski, Assistant State Chemist of the State of Washington. B.O.D. determinations were made by R. G. Tyler and associates in the Disposal Division, Pulp Mills Research, University of Washington.

Vitamin assays for riboflavin, nicotinic acid, and pantothenic acid were conducted on dried yeast samples by the microbiological methods of the Eli Lilly Co. (*6*). Growth of the test organisms in basal media containing the extracts of the yeast samples was compared with that obtained from the basal medium containing known concentrations of the given vitamin by measurement of the turbidity in a Klett-

Summerson Photoelectric Colorimeter. This method for measurement of growth was more rapid and as accurate as by titration of the acid produced. Several microbiological assays for thiamin were tried but none was found to give satisfactory results.

The Yeast Culture

The inoculum was a culture of *Torulopsis utilis* WRRL 954, kindly provided by the Western Regional Research Laboratory in Albany, Calif.

Stock cultures were maintained on slants of Sabouraud's dextrose agar grown at 30°C. and stored in a refrigerator. To prepare inoculum for the propagator, 250 ml. volumes of the sulphite waste liquor being used in the propagator were sterilized by autoclaving for 15 minutes at 120°C. in 1-liter Erlenmeyer flasks described below. After cooling the liquor rapidly, nutrients (sterilized separately) were added aseptically. Each flask was inoculated with a heavy saline suspension of *Torulopsis utilis* grown on agar slants and was incubated for about 24 hours at room temperature on a mechanical shaking machine. The contents of four of these flasks (about 1 liter of pure culture) was then added to the propagator which contained pasteurized sulphite waste liquor. Aeration was started and the culture allowed to grow for about 24 hours to permit the development of a sufficiently large yeast population; continuous addition of feed sulphite waste liquor was then initiated and maintained.

The most effective method found for sterilizing the propagator was heating it, while full of a 1% sodium carbonate solution, to 100°C. by direct steam heat for a day or more. Other equipment, such as the wood barrels used for transporting the liquor, were steamed periodically, or before using.

Nutrients

Phosphorus was added to the liquor as diammonium phosphate. Additional nitrogen was provided as urea or ammonium hydroxide. During part of the operation of the plant, the nutrients were added batchwise to the sulphite waste liquor feed tank. Later, the nutrients in concentrated solution were added to the propagator directly and continuously.

Table I. Operating Data and Calculations for Experiment 1[a]

	1-1	*1-2*	*1-3*	*Av.*
Operating Conditions				
Temp.,[b] °C.	29	30	30	30
Air flow rate, [b,c] l./hr.	1510	1800	1800	1700
Duration of experiment, hr.	24.25	25.17	23.75	...
pH initial SWL	3.70	3.54	3.52	3.6
Density initial SWL, g./ml.	1.068	1.047	1.045	...
Vol. SWL fed, l.	198	205	193	...
Hold-up time, hr.	20.4	20.5	20.6	20.5
SWL Feed Composition				
pH	4.38	4.26	4.20	4.3
N, calcd.,[d] g./l.	1.25	1.25	1.25	1.25
N, by analysis, g./l.	1.28	1.31	1.30	1.30
Reducing substances, g./l.	25.1	25.5	25.8	25.5
Methoxyl, g./l.	8.00	7.77	7.85	...
Ash, g./l.	14.4	12.8	13.8	...
Sulphate, g. SO_3/l.	0.96	1.05	1.09	...
Total solids, g./l.	115.0	116.7	116.7	116
Lead, p.p.m.	1.0	1.3	0.65	...
B.O.D., 1000 p.p.m.	31.1	31.3	30.1	30.8
SWL Effluent (l./l. SWL fed)[c]	0.970	0.956	0.935	0.954
pH	3.97	4.18	4.02	4.1
N, by analysis, g./l.	0.76 (0.74)[e]	0.76 (0.73)	0.81 (0.76)	(0.74)
Reducing substances, g./l.	8.6 (8.3)[e]	8.2 (7.8)	8.0 (7.5)	(7.9)
Methoxyl, g./l.	8.25	8.13	8.40	...
Ash, g./l.	15.8	16.6	15.8	...
Sulphate, g. SO_3/l.	1.02	1.02	1.10	...
Total solids, g./l.	100.0	100.4	100.2	100.2
Lead, p.p.m.	1.0	1.2	0.7	...
B.O.D., 1000 p.p.m.	16.1 (15.6)[e]	15.5 (14.8)	16.8 (15.7)	16.1 (15.4)
Other Results				
N consumed, % of total	42	44	42	43
Reducing substances removed, %	67	69	71	69
Effluent, B.O.D., % of original	50	47	52	50
Yeast conc. in propagator, g./l. SWL	7.3	7.1	7.6	...
Yeast yield, from conc. in effluent, g.	1410	1410	1370	...
Yeast yield, % of reducing substances consumed	42.3	38.8	38.8	40.0
k_{II} for yeast growth, hr.$^{-1}$	21	27	33	26

[a] Feed rate, 8.16 liters per hour; recirculation rate, 150 liters per hour; 167 liters of SWL in propagator; estimated foam/liquid ratio, 0.67/1.0; nutrients, 2 grams of urea, 1 milliliter of ammonium hydroxide soln., and 0.5 gram of diammonium phosphate per liter of SWL, added batchwise to storage tank.
[b] Averages of readings made every 4 hours.
[c] Volume calculated to 0°C. and 760 mm. pressure.
[d] Calculated from the nutrients added, no allowance being made for the nitrogen present in SWL.
[e] Values in parentheses are corrected for evaporation using methoxyl tie basis.

Collection and Presentation of Data

For each experiment, the propagator and other equipment were thoroughly cleaned and then started as described above. After propagator operation had proceeded continuously and apparently at equilibrium for at least 3 days, then a 24-hour experiment was carried out during which frequent records were made of operating conditions and frequent samples of the sulphite waste liquor streams were taken and analyzed. The averages of these data are given, for example,

under experiment 1-1. Then a similar subsequent experiment was conducted for a 24-hour period which led to data for experiment 1-2. The next 24-hour data are indicated as experiment 1-3. The results of the several experiments are given in Tables I through V.

DISCUSSION

Torulopsis utilis or "Torula" yeast was used in the present investigation because of reports indicating its hardy nature, its capacity to consume pentose as well as hexose sugars, and its ability to propagate in the absence of added growth stimulants or vitamins (*1*, *7*). The behavior and characteristics of this yeast have been described recently in a number of excellent papers (*8–20*) most of which have appeared after our work was terminated early in 1947.

Growth Requirements

For growth Torula requires (*7*) a carbon source (glucose, galactose, xylose, glycerol, acetaldehyde, ethyl alcohol, acetic or other carboxy acids, etc.), a nitrogen source (ammonia, nitrates, urea, various amino acids, etc.), the presence of certain inorganic substances (P, K, S, Mg, Ca, and perhaps traces of other elements), and elementary oxygen. If proper environmental conditions exist, then when yeast cells suspended in an aqueous sugar solution are aerated, the sugar is used by the yeast as a food and the yeast cells grow in size and multiply in numbers, producing little alcohol. However, when oxygen is substantially excluded from the system, the sugar may be converted to ethyl alcohol and carbon dioxide and little growth occurs.

For yeast growth on sulphite waste liquor the dissolved sugars serve as the major food supply although other organic solutes such as acetic acid and ethanol may also contribute. The particular sugars present in a Pacific Northwest sulphite waste liquor, similar to that used in present experiments, have recently been determined in these Laboratories (*21*) by chromatographic and other methods to be distributed as follows: mannose, 48%; glucose, 15%; xylose, 15%; galactose, 10%; arabinose, 6%; fructose, less than 2%; and unaccounted for, 4%. This sulphite waste liquor derived from about 85% western hemlock (*Tsuga heterophylla*) and 15% white fir (*Abies grandis*) woods contained relatively less glucose and more galactose than a sulphite waste liquor from a spruce which was examined by Hagglünd and co-workers (*22*).

Our analyses showed present about 26 grams of total reducing substances calculated as glucose per liter of initial sulphite waste liquor, but since some reducing groupings are associated with lignin sulphonic acids (*23*) and probably with other constituents, it is estimated that about 20 grams of actual sugars calculated as glucose were contained in a liter of the sulphite waste liquor used, i.e., 16 or 17 grams of sugars per 100 grams of sulphite waste liquor solids. Since this total is made up of the several individual sugars noted above which may not be used at the same rate or

Table II. Operating Data and Calculations for Experiment 2[a]

	2-1	*2-2*	*2-3*	*Av.*
Operating Conditions				
Temp.,[b] °C.	30	30	30	30
Air flow rate, [b,c] l./hr.	1500	1550	1250	1450
Duration of experiment, hr.	23.75	24.25	21.5	...
Vol. SWL fed, l.	317	324	287	...
N in total nutrients added, g./l. feed	0.55	0.48	0.48	0.50
Hold-up time, hr.	18.4	18.3	18.3	18.3
SWL Feed Composition				
pH	3.40	3.56	3.50	3.5
N, by analysis, g./l.	0.10	...	0.11	0.1
Reducing substances, g./l.	24.5	26.7	26.3	25.8
Methoxyl, g./l.	8.13	...	7.85	...
Ash, g./l.	13.5	...	12.5	...
Sulphate, g. SO_3/l.	1.01	...	1.04	...
Total solids, g./l.	115.3	...	115.6	115.5
B.O.D., 1000 p.p.m.	22.7	...	29.5	26.1
SWL Effluent (l./l. SWL fed)[d]	1.033	...	0.996	1.015
pH	3.83	3.85	4.30	4.0
N, by analysis, g./l.	0.24 (0.25)[d]	...	0.22 (0.22)	(0.24)
Reducing substances, g./l.	7.4 (7.7)[d]	8.2	8.6 (8.5)	8.1
Methoxyl, g./l.	7.87	...	7.88	...
Ash, g./l.	14.3	...	14.0	...
Sulphate, g. SO_3/l.	1.10	...	1.04	...
Total solids, g./l.	94.0	...	95.8	...
B.O.D., 1000 p.p.m.	16.6 (17.1)[d]	...	19.8 (19.7)	(18.4)
Other Results				
N consumed, % of total	62	...	63	62
Reducing substances removed, %	69	69	68	69
Effluent, B.O.D., % of original	75	...	67	71
Yeast conc. in propagator, g./l. SWL	2.9	3.2	3.2	3.1
Yeast yield, from conc. in effluent, g.	950	1030	920	...
Yeast yield, % of reducing substances consumed	17.8	17.2	18.2	18
k_{II} for yeast growth, hr.$^{-1}$	32	25	22	26

[a] Feed rate, 13.35 liters per hour; recirculation rate, 60 liters per hour; 245 liters of SWL in propagator; estimated foam/liquid ratio, 0.03/1.0; nutrients were added continuously to propagator as ammonium hydroxide and diammonium phosphate at a constant N/P weight ratio of 11.5.
[b] Averages of readings made every 4 hours.
[c] Volume calculated to 0°C. and 760 mm. pressure.
[d] Values in parentheses are corrected for evaporation using methoxyl tie basis.

with the same effectiveness by the yeast, the propagation may proceed somewhat differently than is found to be the case with a pure glucose substrate.

For yeast growth to proceed, nitrogen must also be present in not inconsiderable amounts. In preliminary experiments, it was found that sulphite waste liquor yeast contains about 8% total nitrogen. Since sulphite waste liquor itself contains negligible amounts of nitrogen, and since roughly 40% of the weight of sugars consumed appears as yeast, then at least 3.2 grams of nitrogen must definitely be added in nutrients per 100 grams of sugars utilized in yeast growth. About this amount has been used with satisfaction by Peterson (*9*), and Harris and co-workers (*16*) have recommended use of 3.4 grams. In present experiments, nitrogen was added as ammonia or urea and added since these were presumed to be already present in sulphite waste liquor in view of its derivation from woody tissue which had once been engaged in active cell metabolism. However, the data of Harris (*16*) suggest that potassium addition might have been beneficial.

Oxygen is necessary for yeast growth and data cited by Sperber (*7*) indicate that about two molecules of oxygen are required by the yeast per molecule of glucose consumed, i.e., about 120 liters of air at standard conditions per 100 grams of glucose consumed, or perhaps about 20 liters of air per liter of sulphite waste liquor processed. In practice, a substantial excess of air is necessary because of some oxygen consumption by other sulphite waste liquor constituents and because of incomplete absorption of the oxygen fed to

Table III. Operating Data and Calculations for Experiment 4[a]

	4-1	*4-2*	*4-3*	*Av.*
Operating Conditions				
Temp.,[b] °C.	30	29	30	30
Air flow rate,[b, c] l./hr.	6100	5500	5300	5600
Duration of experiment, hr.	22.83	20.78	17.47	...
Vol. SWL fed, l.	186	169	142	...
N in total nutrients added, g./l. feed	0.80	0.64	0.86	0.77
Hold-up time, hr.	6.5	6.6	6.6	6.6
SWL Feed Composition				
pH	3.16	3.35	3.45	3.3
N, by analysis, g./l.	0.09	0.09	0.08	0.09
Reducing substances, g./l.	26.0	25.6	27.7	26.4
Methoxy, g./l.	7.80	7.78	7.92	...
Ash, g./l.	11.90	12.26	11.17	...
Sulphate, g. SO_3/l.	0.96	1.04	0.99	...
Total solids, g./l.	115.8	112.0	117.1	115
B.O.D., 1000 p.p.m.	24.8	25.1	30.3	26.8
SWL Effluent (l./l. SWL fed)[d]	0.980	1.003	0.951	0.978
pH	4.38	4.15	3.95	4.2
N, by analysis, g./l.	0.36 (0.35)[d]	0.25 (0.25)	0.23 (0.22)	(0.27)
Reducing substances, g./l.	11.3 (11.1)[d]	11.6 (11.6)	12.4 (11.8)	(11.5)
Methoxyl, g./l.	7.96	7.76	8.33	...
Ash, g./l.	14.58	13.37	13.60	...
Sulphate, g. SO_3/l.	0.97	1.03	1.02	...
Total solids, g./l.	98.6	97.8	100.4	...
B.O.D., 1000 p.p.m.	11.0 (10.8)[d]	19.9 (20.0)	21.9 (20.8)	(17.2)
Other Results				
N consumed, % of total	61	66	77	68
Reducing substances removed, %	57	55	58	57
Effluent, B.O.D., % of original	44	80	69	64
Yeast conc. in propagator, g./l. SWL	6.5	5.9	4.9	...
Yeast yield, from conc. in effluent, g.	1190	860	670	...
Yeast yield, % of reducing substances consumed	43	37	30	36
k_{II} for yeast growth, hr.$^{-1}$	30	27	26	27

[a] Feed rate, 8.16 liters per hour; recirculation rate, 60 liters per hour; total volume SWL in propagator, 54 liters; liquid level in propagator too low to be visible, but estimated liquid volume not over 10 liters; hence foam/liquid ratio probably over 25; nutrients were added continuously to propagator as ammonium hydroxide and diammonium phosphate at a constant N/P weight ratio of 16.5.
[b] Averages of readings made every 4 hours.
[c] Volume calculated to 0°C. and 760 mm. pressure.
[d] Values in parentheses are corrected for evaporation using methoxyl tie basis.

as diammonium phosphate to the extent of at least 3.2 grams per 100 grams of reducing substances calculated as glucose. In every experiment some nitrogen remained in the spent liquor. Nitrogen actually utilized was found to amount to 2.1 to 4.4 grams per 100 grams of reducing substance consumed (Tables I–IV).

Phosphorus was supplied as diammonium phosphate to the extent of 0.25 to 0.67 gram of phosphorus per 100 grams of reducing substance consumed although this amount was in general somewhat less than that recommended by Peterson (*9*) and later by Harris (*16*), or that apparently used in German practice (*1*). Time did not permit the study of the effect of different concentrations of nutrients. Excepting oxygen, no other substances necessary for yeast propagation were

the propagator. In German operations, about 70 to 100 liters of air was supplied per liter of sulphite waste liquor (*1*) and in present experiments air fed ranged from about 100 to 1200 liters per liter of sulphite waste liquor. No attempt was made to measure efficiency of absorption of oxygen from the air because this depends so specifically on the particular equipment and operating conditions used, and because this type of information can be roughly estimated from data available in the literature (*24*).

Rate of Yeast Growth

The instantaneous rate of growth of yeast is important because it controls the size of propagation equipment or the time required to accomplish the desired degree of conversion to yeast of sulphite waste liquor sugars.

According to Buchanan and Fulmer (*25*) for batch-wise yeast growth, if an aqueous solution of sugars and necessary nutrients is inoculated with a small quantity of yeast, a short lag ensues during which only very slow growth proceeds, and then there follows a first-order growth period wherein the rate of increase in yeast is proportional to the concentration of yeast cells present at that instant:

$$\frac{dY}{d\theta} = k_I Y \qquad (1)$$

where Y is the weight of yeast cells present per unit weight of the solution, θ is the time, and k_I is a first-order growth rate constant. (See Table of Symbols below.) At a later period in a batch system, retarding influences arise and the rate of growth slows down and finally becomes zero because of depletion in food supply, accumulation of toxic waste products of the yeasts, or other causes.

The magnitude of the growth rate constant for a particular strain of yeast in a given propagation may be influenced by aeration, by the nature and concentration of substrate sugars, by the nature and concentration of other nutrients, by the temperature, by the hydrogen ion concentration, and by the nature and concentration of toxic substances, and other factors.

For maximum growth rate, aeration should maintain saturation of the liquid phase with oxygen and aeration and agitation influences have been studied by Peterson and co-workers (*17*). The nature of the sugars in the feed sulphite waste liquor is not subject to the control of a by-product yeast plant operator. However, the concentration of these sugars in the propagator may be an important variable as described below.

Table of Symbols

W_f	= sulphite waste liquor feed rate, lb. per hour
W_0	= propagator overflow rate, lb. per hour
W_e	= centrifuge effluent flow rate, lb. per hour
W_a	= air flow rate, lb. per hour
W_w	= cooling water flow rate, lb. per hour
$W_0 - W_f$	= recycle flow rate, lb. per hour
$W_0 - W_e$	= centrifuge output flow rate, lb. per hour
$W_f - W_e$	= centrifuge product flow rate, lb. per hour
S_f	= concentration of utilizable sugar in feed, lb. per lb. sulphite waste liquor
S_t	= concentration of utilizable sugar in propagator, lb. per lb. sulphite waste liquor
Y_t	= concentration of yeast in propagator, dry lb. per lb. sulphite waste liquor
Y_c	= concentration of yeast in centrifuge cream, dry lb. per lb. sulphite waste liquor
a	= sugars consumed to produce yeast, lb. per dry lb. yeast
V_t	= volume of propagator occupied by liquor and foam, cubic feet
ρ_t	= average density of liquor and foam in propagator, lb. per cubic foot
k_I	= first-order growth rate constant, reciprocal hours
k_{II}	= second-order growth rate constant, reciprocal hours
t_f	= temperature of sulphite waste liquor feed, °F.
t_t	= temperature of propagator, °F.
t_1	= temperature of propagator cooling water entering, °F.
t_2	= temperature of propagator cooling water leaving, °F.
H_1	= humid heat of air entering propagator, B.t.u. per lb. dry air
H_2	= humid heat of air leaving propagator, B.t.u. per lb. dry air
H_3	= heat liberated by generation of yeast, B.t.u. per lb.
d	= differential operator
θ	= time, hours

Necessary nutrients must be provided but it has been found (*16*) that, above low limits, the concentrations of nitrogen and phosphorus seem to have little influence on growth rate. The optimum temperature for Torula growth is in the range of 30 to 35°C. (*10*). A temperature of about 30°C. was used in the German plants (*1*) and also in present experiments; Slator (*26*) has found that the instantaneous rate of yeast growth decreased markedly as lower temperatures were used.

Higher growth rates and yeast yields with decreasing hydrogen ion concentrations were reported by Harris, et al. (*15*), who grew yeast in the range of pH 5 and 6. German operations proceeded at pH 4.5 to 5.0 (*1*). Present experiments were conducted at about pH 4.0 partly because a less persistent foam seemed to be produced than was the case at pH 5 or 6, and partly because it appears that the toxic effects of dissolved sulphur dioxide or its derivatives may be an important factor in fixing the permissible hydrogen ion concentration (*27*). By steam stripping the presently used sulphite waste liquor to remove sulphur dioxide and probably other toxic substances, it is believed that satisfactory operation at higher hydrogen ion concentration was thereby made possible. In one experiment, not reported here in detail, lime neutralization was employed with the result that hydrogen ion control was more difficult and the yeast produced was considerably darker in color than when steam-stripped liquor was fed. Operation at relatively high hydrogen ion concentration may contribute to more efficient utilization of phosphorus which otherwise tends to precipitate as calcium phosphate as neutrality is approached.

Although the instantaneous yeast growth rate is classically represented as a first-order process in which the rate-controlling step may be the conversion into more cell structure of the nutrients with which the cell is saturated, the results of the present limited experiments can be fairly well correlated by using the second-order rate equation:

$$\frac{dY}{d\theta} = k_{II} Y S \qquad (2)$$

Perhaps this correlation succeeds because of the relatively low concentration of sugar maintained in the propagator, or because of the slower rate of consumption of certain sulphite waste liquor sugars which remain present after the yeast has substantially exhausted from the liquor the sugars which are most rapidly consumed. However, since Slator (*26*) seems to have found that sugar concentration becomes a limiting factor only at a concentration around 1 milligram of glucose per liter, and in view of the very limited data at hand, it seems best to regard the equation as merely an empirical relationship.

Sugar Conversions and Yeast Yields

In present experiments, continuous yeast propagation was conducted in a tower (Fig. 1) into which was fed steam-stripped sulphite waste liquor and from which overflowed spent liquor containing the yeast product in suspension. The contents of the propagator were maintained approximately uniform throughout its volume by vigorous aeration, and the

operation was conducted at steady state with respect to time.

Under these conditions the concentration of yeast and of sugars within the propagator adjusted themselves to characteristic equilibrium values which remained approximately constant during each experiment. If the second-order growth rate constant, k_{II}, is really a constant, then throughout each experiment the rate of yeast growth remained the same at some value as indicated by equation (2). From these considerations, numerical values of k_{II} can readily be calculated by setting the yeast input to the propagator by possible recirculation plus the yeast grown equal to the yeast output from the propagator in the overflow:

$$Y_c(W_0 - W_f) + k_{II}Y_tS_tV_t\rho_t = Y_tW_0 \qquad (3)$$

or, from a similar sugar balance, by setting the sugar input to the propagator by possible recirculation plus the sugar entering in the feed equal to the sugar consumed in the propagator plus the output in the overflow:

$$S_t(W_0 - W_f) + S_fW_f = ak_{II}T_tS_tV_t\rho_t + S_tW_0 \qquad (4)$$

where the yeast and sugar balances are related by a sugar-yeast conversion equation:

$$W_f(S_f - S_t) = a(W_0Y_t - W_0Y_c + W_fY_c) \qquad (5)$$

In these equations terms are included to deal with possible recirculation to the propagator of a concentrated yeast suspension from centrifugal separators; while this procedure was not studied in present experiments, it may prove to be useful as a means of increasing steady-state yeast concentration in the propagator and thereby increasing rate of sugar conversion to yeast and making possible use of a smaller propagator. Numerical values of k_{II} for each of the several experiments were calculated from the above equations (2) and (3), rearranged in the form:

$$k_{II} = \frac{\frac{dY}{d\theta}}{YS} = \frac{\left(\frac{Y_tW_0 - Y_c(W_0 - W_f)}{V_t\rho_t}\right)}{Y_tS_t} = \frac{W_0}{S_tV_t\rho_t} \qquad (6)$$

and assuming that the sugar concentration in the propagator tower, S_t, is represented by the experimentally found value of reducing substance minus a constant value of 6 grams per liter of reducing substances represented in lignin sulphonates and other components which are not usable by the yeast as food. The surprising constancy of the values of k_{II} found for the several experiments indicates the practical utility of the second-order rate formulation as a means of correlating the effects of operating variables in the same system.

For preliminary estimation of the most economical combination of operating conditions for yeast propagation, the above equations may be useful as well as the following equation stating a heat balance around the propagator:

$$W_ft_f + (W_0 - W_f)t_t + H_3Y_c(W_f - W_e) = W_0t_t + W_a(H_2 - H_1) + W_w(t_2 - t_1) \qquad (7)$$

assuming that the specific heats of sulphite waste liquor and of a yeast slurry are unity, and neglecting: heat losses from the propagator to surroundings, heat losses from recycled yeast slurry, sensible heat and heat of solution of nutrients if these are added to the propagator, and heat dissipated in the reactor by stirring. The heat evolved per unit weight of yeast produced, apparently including heat equivalent to work of stirring, has been reported (*1*) to be 4500 calories per kilogram (8100 B.t.u. per pound).

The individual experiments summarized in the tabulations differed in several ways but can be compared on a basis of "retention time," i.e., the average

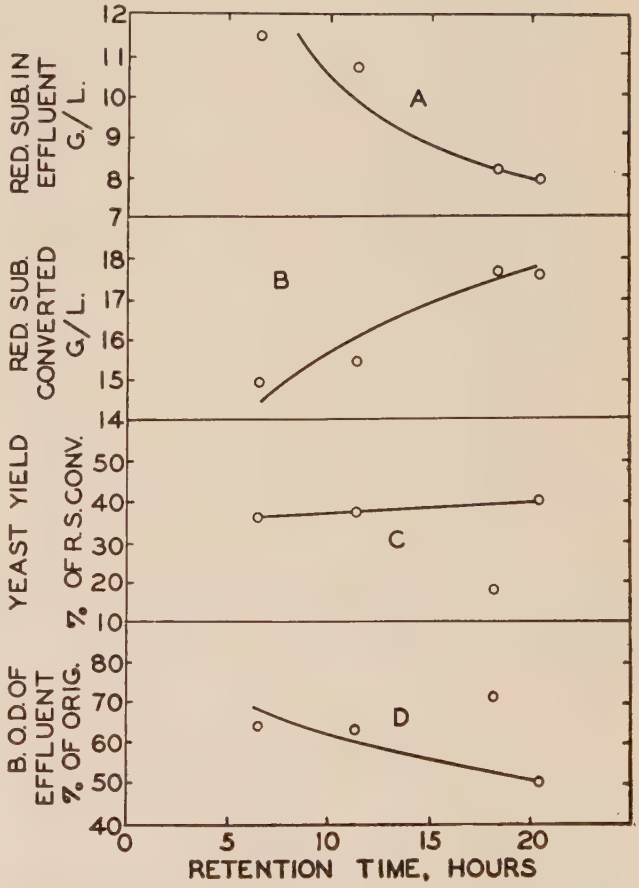

Fig. 2. Effect of retention time on propagation operation

2A. Effect of time on effluent reducing substances
2B. Effect of time on reducing substance conversion
2C. Effect of time on yeast yield
2D. Effect of time on effluent B.O.D.

period of time in hours during which a differential volume of sulphite waste liquor was retained in the propagator (*28*). The retention time is equal to the total weight of sulphite waste liquor in the propagator at any instant divided by the weight feed rate. As the retention time is increased, the conversion of reducing substances progressively increases toward an asymptotic value of 18 to 20 grams per liter (Figs. 2A and B) which apparently represents all the reducing substances in this sulphite waste liquor which yeast can readily utilize for its growth. As indicated in the tabulations, this amounts to a removal of up to about 70% of the total reducing substances present as in-

dicated by our method of analysis. However, since considerable reducing substances are associated with the lignin sulphonates (*23*), the consumption of reducing sugars in present experiments was actually considerably higher, probably up to 80 or 85%. Although differences in analytical procedures and methods of expression of results make difficult comparison of these data with others, the following sulphite waste liquor sugar utilization figures have recently been reported: about 90%, by Walker and Morgen (*10*); about 79%, by Harris (*12*); 75 to 79%, by Harris in a later paper (*15*); and 70 to 77%, by Tyler and Maske (*18*) who used about the same sulphite waste liquor as we did.

In the present experiments, excepting the obviously irregular experiment 2, the yeast yield, based on reducing substances converted, remains approximately constant at about 36 to 40% by weight (Fig. 2C). This yield is perhaps slightly better than that of 35% reported from German practice (*1*), about the same as a figure of 39% reported by Harris, et al. (*15*), but lower than other yield figures in the range of 40 to 46% given by Tyler and Maske (*18*) or of 50% given by Harris (*12*).

Table IV. Operating Data and Calculations for Experiment 5[a]

	5-1	5-2	5-3	Av.
Operating Conditions				
Temp.,[b] °C.	30	30	30	30
Air flow rate,[b, c] l./hr.	4900	5000	5200	5000
Duration of experiment, hr.	19.05	26.25	19.23	...
Vol. SWL fed, l.	79	109	80	...
N in total nutrients added, g./l. feed	0.85	0.81	0.58	0.75
Hold-up time, hr.	14.5	14.5	14.5	14.5
SWL Feed Composition				
pH	3.32	3.34	3.41	3.4
N, by analysis, g./l.	0.08	0.09	0.07	0.08
Reducing substances, g./l.	28.6	25.7	23.9	26.1
Methoxyl, g./l.	8.48	7.49	7.55	...
Ash, g./l.	11.8	9.6	12.9	...
Sulphate, g. SO_3/l.	0.84	0.86	1.09	...
Total solids, g./l.	122.2	104.4	111.0	113
B.O.D., 1000 p.p.m.	36.0	33.2	34.0	34.4
SWL Effluent (l./l. of SWL fed)[d]	1.010	0.913	0.889	0.938
pH	3.60	3.62	3.76	3.7
N, by analysis, g./l.	0.17 (0.17)[d]	0.17 (0.15)	0.12 (0.11)	(0.14)
Reducing substances, g./l.	12.3 (12.4)[d]	11.9 (10.9)	9.8 (8.7)	(10.7)
Methoxyl, g./l.	8.40	8.20	8.49	...
Ash, g./l.	13.3	12.6	12.8	...
Sulphate, g. SO_3/l.	0.90	0.97	1.05	...
Total solids, g./l.	98.6	98.7	97.7	...
B.O.D., 1000 p.p.m.	22.6 (22.8)[d]	22.4 (20.5)	23.0 (20.4)	(21.2)
Other Results				
N consumed, % of total	82	83	83	83
Reducing substances removed, %	57	58	64	60
Effluent, B.O.D., % of original	64	62	60	62
Yeast conc. in propagator, g./l. SWL	5.2	5.9	7.1	...
Yeast yield, from conc. in effluent, g.	410	590	510	...
Yeast yield, % of reducing substances consumed	32	37	42	37
k_{II} for yeast growth, hr.$^{-1}$	11	14	25	17

[a] Feed rate, 4.15 liters per hour; recirculation rate, 60 liters per hour; liquid level in propagator, too low to be visible but estimated liquid volume is not over 10 liters, hence foam/liquid ratio probably over 25; nutrients were added continuously to propagator as ammonium hydroxide and diammonium phosphate at a constant N/P weight ratio of 16.5.
[b] Averages of readings made every 4 hours.
[c] Volume calculated to 0°C. and 760 mm. pressure.
[d] Values in parentheses are corrected for evaporation using methoxyl tie basis.

The B.O.D. of the yeast plant effluent also decreases progressively as conversion or retention time is increased, and the maximum reduction found in present experiments was to about 50% of the original value (Fig. 2D). Tyler and Maske (*18*) have indicated 35 to 50% B.O.D. removal from sulphite waste liquor while Holderby and Wiley (*20*) state that 70 to 75% removal is practically attainable. These apparently wide differences in results may arise because of differences in B.O.D. analytical procedures or because of differences in degree of acclimatization of organisms (*13*).

Table V. Analyses of Sulphite Waste Liquor Yeasts[a]

Experiment[a] 1-3	2-3	4-1	4-2	4-3	5-1	5-3	*Composite*[b,c]
Ash, %	6.21	6.63	7.22	7.27	9.12	7.93	5.10	7.58
Kjeldahl nitrogen, %	7.96	7.91	8.32	8.35	8.49	8.23	7.94	8.56
Nicotinic acid, γ/g.	295	305	415	395	495	520	242	...
Pantothenic acid, γ/g.	114	64	67	62	63	50	90	...
Riboflavin, γ/g.	...	52	56	54	50	49	43	...

[a] See Tables I–IV for conditions under which these yeasts were produced. Analyses are here reported on basis of bone-dry yeast.
[b] Composite sample prepared by mixing various yeasts obtained under conditions similar to those used in experiment 1.
[c] Other analyses on this composite sample reduced to moisture-free basis yielded the following results: CaO, 0.13%; Fe, 0.01 to 0.05%; S, 0.45%; sulphate as SO_3, 0.00%; sulphate in ash, 0.00%; arsenic as As_2O_3, 1 p.p.m.; Pb, 14 p.p.m.; methoxyl, 0.82%.

In the anomalous experiment 2, sugar conversion was about that to be expected from retention time used. However, the poor yeast yield and reduction of B.O.D. indicate that in this case aeration was inadequate so that considerable sugar, instead of being converted to yeast, was converted to substances which remained present in solution to contribute to the B.O.D. This result emphasizes that both adequate retention time and also adequate aeration must be provided to secure maximum conversion of sugars to yeast. A contaminating yeast grew in the propagator in substantial amount during this experiment and may have contributed to the anomalous results. While the presence of foam is probably importantly associated with adequate aeration as emphasized by Tyler and Maske (*18*) yet there must be some optimum density of an air-liquid mixture in a given propagator since, with a constant rate of feed to an effectively mixed propagator of some fixed volume, the greater the proportion of air present per unit volume of sulphite waste liquor, the lower the retention time and consequently the lower the extent of conversion of sugars.

Contamination of the pure culture of Torula by other organisms was frequently observed during the period of operation of the plant before the data presented here were obtained. One contaminant found was a large round-celled yeast which grew profusely in the propagator liquid in long stringy masses; this yeast formed a pseudomycelium when grown on agar medium and was tentatively identified as a member of the genus *Torulaspora*. Another very persistent contaminant was a smaller elliptical yeast which formed long branched chains and was thought to be a member of the genus *Mycoderma*. In spite of exhaustive attempts to clean the equipment, contamination would appear about 1 week after starting up continuous operation with a pure culture and, within a few days, would become serious. There was some contamination throughout experiment 2, encouraged probably by the presence of a large volume of liquid phase. Slight contamination appeared near the end of experiment 5 after 10 days of continuous operation. These organisms possibly entered the system in the sulphite waste liquor barrels or in other equipment in spite of prolonged steaming and other efforts to accomplish sterilization. However, it seems probable that the air was the principal source of trouble although feed air was filtered through a tight plug of glass wool. It is believed that contamination would be minimized by use of freshly stripped sulphite waste liquor and of sterilized air. Harris (*15*) found less contamination as acidity of the propagator liquid was increased.

Yeast Characterization

The yeast was recovered in present experiments by centrifuging, washing thoroughly with water, and then drying in a thin film in a vacuum tray drier. The dried yeast is a brittle brown material which forms a light brown powder on grinding. Some chemical analyses of yeasts produced in the individual experiments and of a composite sample are given in Table V.

The protein content (assumed to be 6.25 times the percentage of Kjeldahl nitrogen) of the present yeasts averages around 53%. Analyses of a Torula species by Sperber (*7*) show considerable variations depending upon conditions of propagation but his values for protein varied from 44 to 56%, and for ash from 6 to 11%. Harris' sulphite waste liquor Torula yeast contained 51 to 53% protein (*15*). Our yeast contained 6.2 to 7.9% ash, substantially no sulphate, and very little calcium (Table V). Arsenic was well within the limits recommended by Jacobs (*29*) as safe for human consumption. However, the lead content proved to be about twice the recommended limit (*29*) and this lead apparently came from the feed sulphite waste liquor.

The vitamin contents of the yeast produced seem comparable with those of similar yeasts (*11*, *17*) including a German sulphite waste liquor yeast on which we made vitamin assays. Small differences are probably not significant unless the yeasts are dried and stored under identical conditions since minor variations in these operations may have considerable effect. For example, a sample of our yeast was divided into three parts and each part was dried by one of the following procedures: sample A, in a tunnel drier at about 50°C. at 1 atmosphere for 20 hours; sample B, in a vacuum oven at 60°C. at 12 mm. Hg pressure for 15 hours; sample C, under high vacuum always in a frozen state. For samples A, B, and C, respectively, the following average assays were obtained expressed in parts per million: riboflavin, 44, 38, and 33; nicotinic acid, 284, 162, and 458; pantothenic acid, 110, 142, and 110.

The yeast produced has been used in feeding experiments the results of which will be reported elsewhere.

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Received July 1, 1949 (Revised Dec. 18, 1950). Presented at the Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 21–24, 1949.

The writers are grateful to L. E. Sacks and D. Pennington for preliminary experimentation, to J. Sundling for assembly of some equipment, to J. Farnsworth, W. Mowery, R. Murray, R. Brewer, A. Inerfield, and W. Maske for aid in plant operation, to V. Felicetta for some analyses, to Miss P. McDowell for some culture preparation, to Carl Kuether of the University of Washington and James McGinnis of the State College of Washington for yeast feeding experiments, and especially to R. G. Tyler of the Disposal Division of Pulp Mills Research at the University of Washington for his cooperation.

Friction Pressure Drop in the Flow of Paper Pulp Stock

THOMAS E. GUENTER and N. H. CEAGLSKE

Data were obtained in a 1-inch smooth copper pipe for velocities ranging from 1 to 15 feet per second and for pulp consistencies of 1.16 to 2.73%. The method of correlation used depends on the validity of the Fanning friction factor plot for non-Newtonian fluid flow. Results show that the effective viscosity of the pulp goes through a maximum at fluid velocities in the range of 2 to 5 feet per second and then decreases sharply with increasing velocity. The consistency has a large effect on the viscosity and pressure drop. The viscosity of the lowest consistency (1.16%) showed a decided tendency to approach a constant value at high velocities; this stock also demonstrated behavior similar to water and different from other consistencies. The pressure drop versus velocity plots showed the same maxima and minima as indicated by Brecht and Heller, and Forrest and Grierson. The data from this investigation fill out regions not covered by the aforementioned articles. The flow nozzle, employed to give a continuous indication of flow rate, worked very well and lent advantageous flexibility to the operation.

The primary purpose of this investigation was to attempt to develop a method of correlation for the pressure drop of paper pulp flowing in pipes. The present paper is the first step in the project, and the results are being presented to possibly aid and encourage others to carry on this work.

LITERATURE REVIEW

The predominant impression obtained from the literature is that there are very few investigations which present new or substantiating data. An early paper by Trimbey (*7*) is of little use because spiral riveted pipe was used. Two papers are evident throughout as being useful in their contributions. The tests of Forrest and Grierson (*4*) produced curves for four sizes of cast iron pipe. Their testing arrangement seems to be questionable because of insufficient calming length. The extent of their investigation was limited to two types of stock in cast iron pipe, and no method of correlation was presented.

A paper by Brecht and Heller (*3*) is a very complete work on several phases of the subject. This presentation includes velocity profiles, the effect of pulp consistency, seven different kinds of pulp, pipe diameter, degree of beating, average fiber length, temperature, and fillers. Their testing arrangement also has a short hydraulic calming length. The data in this work are presented without any attempt to correlate the data. Some of the sections of their investigation produced results which followed irregular patterns, e.g., the effect of type of stock and degree of beating. No mechanism was proposed to account for any of the results obtained.

Brautlecht and Sethi (*2*) have studied consistencies up to 1.57%. They applied the laws for water to their case, but substantiated the phenomena that dilute suspensions show lower friction losses than water.

Moss and Bryant (*6*) have made a photographic study of the flow of fibers and water.

An investigation of viscosities of pulp stocks was made by Gray and Van den Akker (*5*). Their tests seem to have been well conducted, but unfortunately their conclusions were not borne out too well by Brecht and Heller or in the present investigation. There is agreement, however, on two points; namely, that the viscosity and flow properties of groundwood and kraft pulps are entirely different, and that low consistencies act the same as water.

A recent paper by Alves (*1*) outlines a method of obtaining viscosity indirectly through use of the standard friction factor plot. This article deals with non-Newtonian fluid flow in general, and the suggested method of correlation has been used herein.

The paper by Brecht and Heller (*3*) contains a more extensive survey of the literature. It can be referred to for a more complete coverage, but the critical papers are reviewed in this section.

APPARATUS

The details of construction of this equipment played an important part in obtaining true readings and trouble-free operation. Hence a fairly complete description of the apparatus will be given. In most cases, the changes and innovations of standard practice were to allow for the suspended pulp. Both Brecht and Heller (*3*) and Forrest and Grierson (*4*) used large pipe in their investigations (4 to 12 inch) but the facilities available would not permit duplication of these sizes, therefore 1-inch copper pipe was used.

It will be noted in Fig. 1 that a calming length of 13 feet separated the first pressure tap from the flow control valve. This amounts to 157 pipe diameters, which

Thomas E. Guenter, Chemical Engineer, E. I. du Pont de Nemours and Co., Inc., Niagara Falls, N. Y.

N. H. Ceaglske, Professor of Chemical Engineering, University of Minnesota, Minneapolis, Minn.

is entirely adequate by water standards, to assure a well-established flow pattern by the time the measuring sections are reached. It was felt that both Brecht and Heller (*3*) and Forrest and Grierson (*4*) had questionably short calming lengths in their equipment. The former had about 15 diameters after a run-of-tee following the centrifugal pump; the latter specified 8 diameters following the entrance of the pulp into the test lengths through the side outlet of a tee. The test sections were part of the continuous run of pipe, i.e., there was no union or flange joining a short measuring section to the long calming section. To maintain a stable flow pattern and introduce as little disturbance as possible while reversing the flow direction, the wide radius bend indicated in Fig. 1 was used. This semicircle was connected to the straight pipe with gasketed flanges. The flow nozzle section and a second test section, preceded by a calming length of 60 pipe diameters, were about 4 feet higher than the other straight length.

mixer with a 5-inch high pitch propeller was also put into the feed tank during later runs. This gave excellent mixing results.

It was found that globe valves were entirely unsatisfactory for handling pulp. Ordinary gate valves worked well and are recommended unless special valves designed for handling pulp are available.

A Worthington open impeller centrifugal pump (rated 50 g.p.m. at 20-foot head, 1800 r.p.m.) handled all consistencies of pulp, provided a 6-foot head was maintained on the suction side when handling consistencies over 2.25%. The pump was driven by a $^3/_4$ h.p. three-phase electric motor and V-belt on a four-step pulley.

The pressure taps were constructed by drilling holes in the pipe with care being taken to remove any burr on the inside of the pipe. A 0.125-inch hole was made to avoid plugging during runs, which is somewhat larger than normally used. Distance between taps was accurate to $^1/_{16}$ inch. By making the test sec-

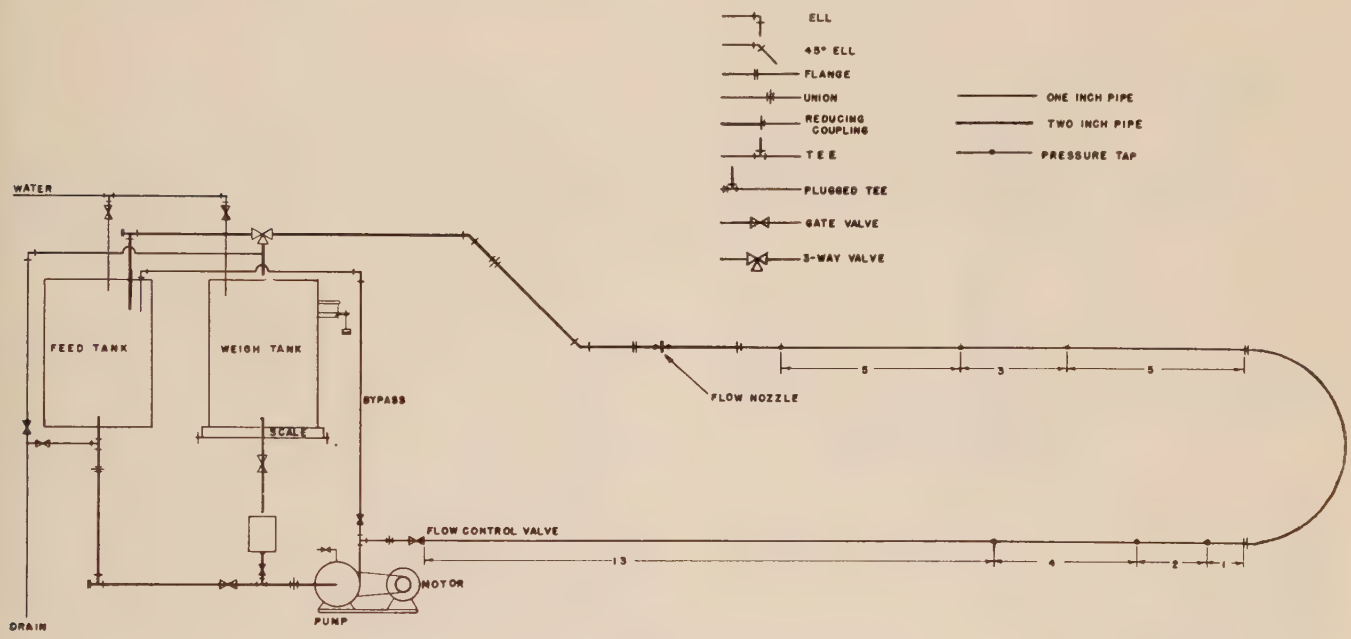

Fig. 1. General piping layout

Two-inch pipe was used following the upper test section because it was felt that a flow nozzle inserted in a 1-inch line would cause plugging; furthermore, it was desired to reduce any additional losses between the last pressure taps and the tanks.

The pipe in the straight test sections was copper water pipe measuring 0.991 inch inside diameter. The inside surface was mirror smooth, both before installation and after completion of the tests. The long radius bend was 1-inch galvanized steel pipe. All other pipe, nipples, and pipe fittings were galvanized steel except the valves which were brass. The three-way steam cock over the weigh tank permitted the flow to be diverted rapidly from the feed tank to the weigh tank. In the first runs, the discharge end of the main pipe line extended to the bottom of the feed tank into a 90° ell which diverted the stream tangentially to help mix the slurry. But it was found that better mixing was obtained if the discharge was straight down and about 4 inches below the pulp level in the tank. A Lightning

tions of several lengths it was possible to measure the drop across lengths of 2, 3, 4, 5, 6, and 8 feet of pipe. The shorter lengths were used at high velocities so that the manometer range was not exceeded. The longer lengths gave a larger total pressure drop at low velocities. By locating test sections at various distances along the length of the pipe, it was possible to determine if the calming section was sufficiently long, and if the pressure drop was dependent on the length of the pipe as proposed by Gray and Van den Akker (*5*). The center line of the taps was 5° below horizontal. Very little pulp settled by gravity into the manometer lines and the troublesome air bubbles, apparently entrained in the beaten pulp, did not collect and rise into the lines as they did when the taps were vertical upward.

Of primary importance in the flexibility and ease of operation was the flow nozzle used in the main line. Figure 2 shows the details of the construction and method of insertion between the machined flanges. The diameter of the throat was arbitrarily determined

from a standard equation for water since the pressure drop was expected to be due almost entirely to velocity change rather than properties peculiar to the pulp. The rounded entrance was only approximately a quarter circle, but nonetheless perfectly smooth and polished, as was the throat. Calibration was imperative in any case, so an exact contour was considered unnecessary. All other investigators (*3*, *4*) have used some method of volume or weight measure to determine flow rates. Results of these experiments show the usefulness of a calibrated flow nozzle to determine flow rates (at least up to 3% consistency). Pressure taps on either side of the nozzle were 0.250-inch holes, and otherwise the same as the test section taps.

A 5-inch Hollander was used to beat the pulp. The unit was placed so that the belt drive could be switched from the pump to the beater.

The manometers were standard two-fluid units using carbon tetrachloride as the heavy liquid. By means of a manifold and three-way valves any of the lower three

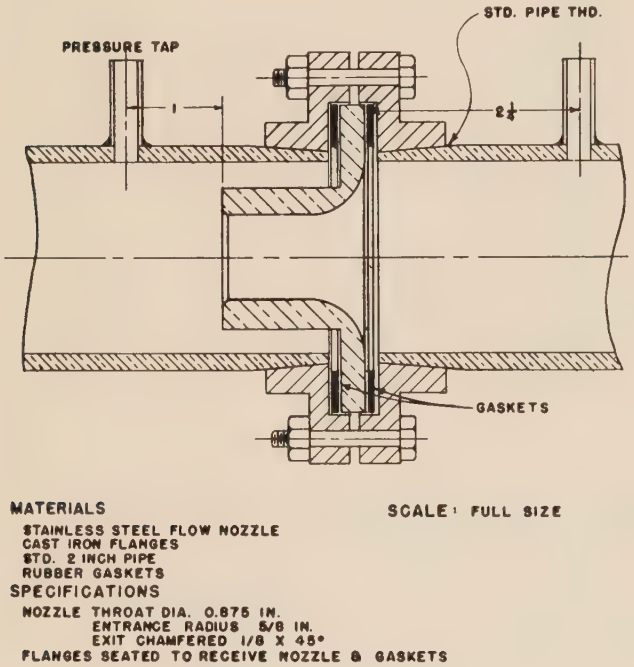

Fig. 2. Flow nozzle

pairs of taps (i.e., sections of 2, 4, or 6 feet) could be connected to the manometer. A similar unit was used for the upper set of taps. For the flow nozzle a simple mercury manometer was used. Fresh water flushing connections were provided on all three manometers.

Unbleached sulphite pulp was obtained in wet lap form through the courtesy of the Kimberly-Clark Corp., Neenah, Wis.

OPERATION

The flow nozzle was calibrated by the usual method of weighing the water or pulp stock flowing.

During the friction drop runs the manometer lines were cleared of air or pulp by flushing. The rate of flow was determined by the flow nozzle. Freeness tests are made with the standard Schopper-Riegler apparatus and refers to 2 grams of moisture-free sample.

METHOD OF CORRELATION

From the quantities measured in the experimental procedure, a friction factor was computed according to the Fanning equation:

$$f = \frac{\Delta p}{\rho} \frac{Dg_c}{2Lv^2} \qquad (1)$$

where:

f = friction factor, a function of N_{Re}
Δ_p = pressure drop, lb. per sq. ft.
L = length of pipe in feet
ρ = density, lb. per cu. ft.
D = pipe diameter, ft.
g_c = gravitational constant
v = velocity, ft. per sec.
N_{Re} = Reynolds number = $\frac{Dv\rho}{\mu}$
μ = viscosity, lb. per sec. ft.

Proceeding to the well-known plot of f versus N_{Re} a Reynolds number was found corresponding to the friction factor. The quantities D, v, and ρ of the Reynolds number were known, leaving μ to be computed, or

$$\mu = \frac{Dv}{N_{Re}} \qquad (2)$$

This effective value when plotted against the corresponding velocity produced a good correlation of the data. The assumption was made that the plot of f versus N_{Re} is perfectly general for flow, whether of Newtonian or non-Newtonian fluids in the turbulent zone. The value obtained for μ should be recognized as an effective viscosity.

The characteristic line on the friction factor plot in the turbulent range for the mirror-smooth copper pipe in the apparatus lay below the average line for "smooth pipes," but within the band of points accumulated from many investigations. Friction runs with water determined the position of this characteristic line. In the laminar range, the line $f = 16/N_{Re}$ was used. Between f values from 0.005 to 0.12 there is possibility of two Reynolds numbers. Since all pulp runs were taken from high to low velocity, the turbulent line was followed to a Reynolds number of 2000 to 2500. (At this point the difference between values from either curve would not have significant effect on the shape of the μ versus velocity curve.)

When Brecht and Heller's data were used, values of $\Delta p/\rho$ for equation (1) were taken from their smooth curves. Reynolds numbers were taken from the characteristic line for copper pipe in the turbulent zone of the friction factor plot and the same procedure was used to obtain μ.

An attempt to obtain viscosity measurements with a Brookfield viscosimeter was unsuccessful. The instrument measures the torque required to turn spindle-immersed in a fluid; extremely erratic readings registered because the spindles dug a hole in the pulp and revolved mostly in a pool of water.

DISCUSSION OF RESULTS

The three flow nozzle calibration runs at consistencies of 1.22, 1.50, and 2.66% were spaced over the entire range of consistencies used. Figure 3 shows both the curves obtained for water and pulp although the points are for pulp only. In determining velocity from the weight rate, the bulk density of the pulp used was

that of water. Density tests taken on pulp samples deviated from water densities only by experimental error.

An interesting side light may be mentioned. If the calibration curves for pulp and water are plotted as log v versus log Δp, the water curve has a slope of 2

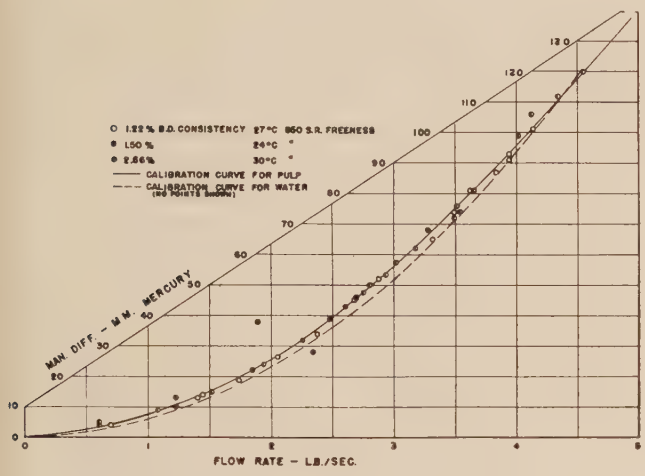

Fig. 3. Flow nozzle calibration

but the pulp curve has a slope of 1.85. This indicates that the pressure drop across the nozzle is proportional to v^2 for water as would be expected from a brief analysis of the modified Bernoulli equation.

Pressure Drop

Friction drop readings were taken in millimeters of carbon tetrachloride-water and converted to pounds per square feet per foot of pipe.

Since the temperature was relatively constant, densities at the average temperature were used for CCl_4 and H_2O.

The readings on the manometer legs were steady at velocities above dip in the pressure drop curve, but in regions below this, the legs fluctuated about 5 to 20 mm. Mean values were recorded. Starting from a high velocity, and decreasing by small steps, a definite and smooth curve could be "brought around the dip" and up to a maximum. But these points were not exactly reproducible either individually or by again starting at a high (stable) velocity. However, any series of points taken either from high to low or low to high velocities in this area always showed an increase in the proper direction. At higher consistencies the points in the dip region scattered more but showed the same characteristics. Only a few points could be obtained on the low velocity side of the maximum because the flow control valve was easily plugged at these low rates.

It is important to note that the 1.16% pulp gave a curve with no dip and maximum and that it was very similar to the water curve (see Fig. 4). This pulp curve crossed the other pulp curves so that a cross plot of Δp versus consistency will show a minimum between 1 and 2% at velocities greater than 7.75 feet per second. Brecht and Heller's data are substantiated on this point.

For velocities above 11 feet per second the friction pressure drop of all pulp stocks (highest of 2.73%) was less than that for water. There is no indication that the pulp curves approach the water curve at higher velocities, but they appear to approach a constant slope different from water, with the exception of the 1.16% curve. This trend had not been definitely established by other investigations.

Another characteristic of the results shown in Fig. 4 is that the maxima and minima occur at higher velocities with increasing consistency. The dip also becomes wider.

The curvature approaching the origin in Fig. 4 has not been definitely established. At velocities below 2 feet per second errors in reading the manometers are so large that the results are only an indication as to the trend of the curve.

Observing the readings in the different test sections along the length of the pipe showed that there was no variation in the pressure drop due to length of pipe in any velocity range. The last tap in the flow line developed a faulty valve in the manifold so readings from this 5-foot section were not used.

The Schopper-Riegler freeness of the stock varied from 850 to 830 ml. In this region, according to Brecht and Heller, there is no effect of freeness on pressure drop. The temperature coefficient which these investigators found was 0.012 feet head loss per °C. per 100 feet of pipe (for bleached sulphite 780 S-R freeness). Data in this paper were not corrected to a standard temperature.

Viscosity Correlation

In determining the Reynolds numbers, a large reproduction of the friction factor plot was used to read

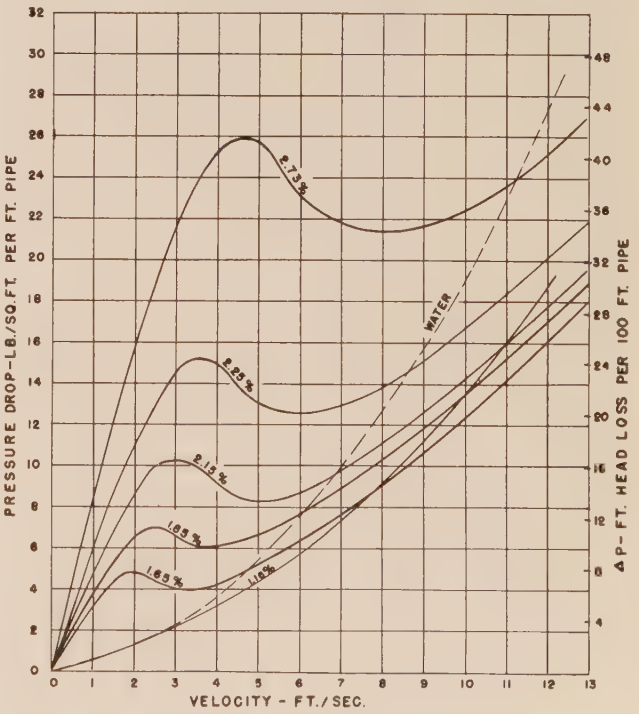

Fig. 4. Pressure drop vs. velocity

values. The characteristic curve was determined by computing the Reynolds number with standard viscosity data for water; the corresponding friction factor was computed from measurements as outlined in the method of correlation (equation 1). These points, it is realized, were over a short region, but the curve was

extended parallel to the mean value curve of Walker, Lewis, McAdams, and Sherwood (*8*).

Since this curve has a very small slope in the turbulent region, the Reynolds number (or viscosity) is very sensitive to the location of the curve. In fact, the difference between the curve characteristic to the mirror smooth pipe herein, and the mean value curve almost doubled the viscosity values. Hence it is not

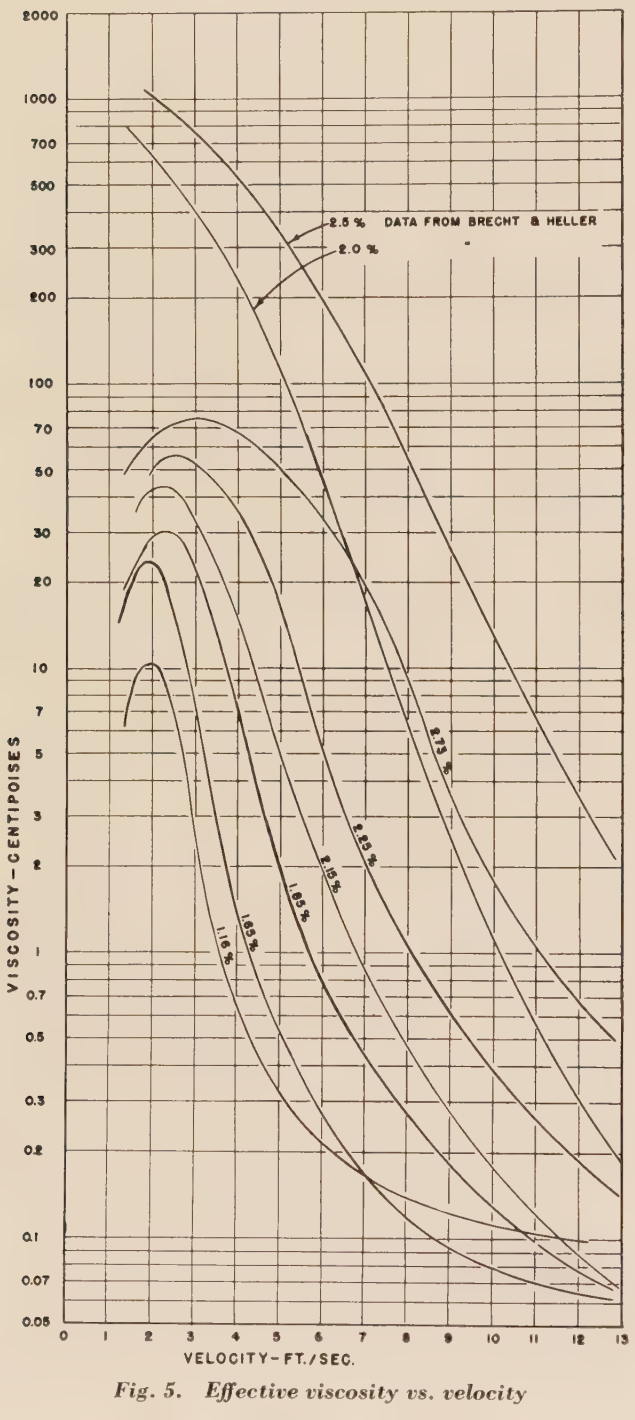

Fig. 5. Effective viscosity vs. velocity

at all surprising that the use of this characteristic curve for Brecht and Heller's data caused the viscosities to be somewhat higher than those found in the present investigation.

Inspection of Brecht and Heller's data shows that the data from two different pipe diameters can be represented by a single curve for each consistency. Comparison of these curves (for 2.0 and 2.5% consistency) with the present data shows that the two sets have about the same shape, and the maxima occur at about the same velocity. It is felt that if a characteristic friction factor line was available for their two sizes of pipe, their curves would be displaced into the region of the present data.

The wide scattering of viscosity points for 1.16% consistency indicates a tendency toward constant viscosity. If the viscosity of water is computed by the method of correlation used here, i.e., from the smoothed characteristic friction factor line (which was drawn through points determined by using a constant μ for water), a scattering of points is obtained around the constant value similar to the scattering at the lower end of the μ versus velocity curve for 1.16% pulp. This is the only pulp curve which showed a decided tendency to level off.

In Fig. 5, the curves appear to be approaching a constant value somewhere near 0.05 cp.; however, there is not a good indication that the higher consistencies approach a constant value.

SUGGESTIONS FOR CONTINUED WORK

In view of the completeness of Brecht and Heller's investigation, it is felt that an effort should now be made to substantiate or develop a method of correlation. The foremost need in further work is to extend the range of consistencies up to 10 or 12%. This would require a forced feed on the pump suction and further refinements of the equipment. A section of transparent pipe could reveal visible changes in the flow pattern at critical points. Moss and Bryant (*6*) have outlined a method of spark photography which might be helpful in recording changes. A successful means of measuring viscosity separately and directly would supply much needed information.

Work can, of course, be extended in the phases investigated by Brecht and Heller (*3*), but a successful method of correlation in one phase might simplify the irregularities observed in others.

The mechanism of flow is much more complicated than for Newtonian fluids. Therefore, in addition to the more practical aspects of this problem some work should be done on the fundamental mechanisms involved with an attempt made to develop theoretical mathematical relationships.

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Received Dec. 15, 1950. Presented at the Engineering Conference sponsored by the Technical Association of the Pulp and Paper Industry, Cincinnati, Ohio, Oct. 2–5, 1950.

ASSOCIATION NEWS AND EVENTS

TAPPI Coating Conference

Following is the revised and final program of the Coating Conference of the Technical Association of the Pulp and Paper Industry to be held at the Statler Hotel, Boston, Mass., on April 18–20, 1951.

Meetings of April 18, 1951

R. T. Trelfa, Hercules Power Co., Wilmington, Del., *Chairman*

Symposium on Raw Stock Requirements for Coated Paper

1. Introduction by Norman I. Bearse, Vice-President, Champion-International Co., Lawrence, Mass.
2. "Requirements for Hanging Stock," by Thomas La Haise, Superintendent, Paper Mill Division, Imperial Paper & Color Corp., Plattsburg, N. Y.
3. "Requirements for Off-Machine Board," by A. T. Luey, Engineer, Sutherland Paper Co., Kalamazoo, Mich.
4. "Requirements for Off-Machine Book," by A. Lewenstein, Technical Director, Appleton Coated Paper Co., Applet on, Wis., and P. Hansen, Bergstrom Paper Co., Neenah, Wis.
5. "Requirements for On-Machine Board," by W. C. Hunter, Asst. to Plant Manager, New Haven Pulp and Board Co., New Haven, Conn.
6. "Requirements for On-Machine Book," by J. E. Wilber, St. Regis Paper Co., Defariet, N. Y.
7. "Requirements for On-Machine Publications," by Paul J. Thoma, Consulting Engineer, Time, Inc., Springdale, Conn.

Meetings of April 19, 1951

A. D. Bonanno, Champion-International Co., Lawrence, Mass., *Chairman*

1. "The Trist Paper Coating System," by A. Ronald Trist, Trist Colloid Products Patented, New York, N. Y.
2. "Brightness and Opacity of Certain Pigmented Coatings," by J. Frankewicz, Technical Director, and J. Senuta, Chemist, Champion-International Co., Lawrence, Mass.
3. "Partial Structure and Flow Properties of Coating Clays," by C. G. Albert, Director of Research, Edgar Bros. Co., McIntyre, Ga.
4. "A Preliminary Study of Particle Size of Clay, Its Determination and Effects," by F. Masterman, Research Chemist, Provincial Paper Ltd., Toronto, Ont.
5. "The Mechanism of Gloss Development in Clay-Coated Papers," by S. Lyons, Technical Director, Georgia Kaolin Co., Dry Branch, Ga.

Luncheon Address "Feast or Famine" by George Olmsted, Jr., President, S. D. Warren Co., Boston, Mass.

Meetings of April 20, 1951

1. "The Requirements of Coated Paper for Offset Lithography," by W. H. Bureau, Research Dept., Butler Paper Co., Chicago, Ill.
2. "Comparative Study of Various Starches," by Gordon I. Hoover, Provincial Paper Ltd., Georgetown, Ont.
3. "The Hercules Print Tester," by E. J. Barber, Research Chemist, and J. W. Davis, Research Supervisor, Hercules Powder Co., Wilmington, Del.

The Committee wishes to encourage questions for discussion on raw stock problems. These questions will be given consideration if sent to A. D. Bonanno, Program Chairman, Champion-International Co., Lawrence, Mass., by April 10, 1951.

Room reservations should be made without delay with V. W. Ringer, Statler Hotel, Boston, Mass. (Mention TAPPI Coating Conference).

John H. Heuer of A.P.W. Products, Inc., Albany, N. Y., is Chairman of the TAPPI Coating Committee.

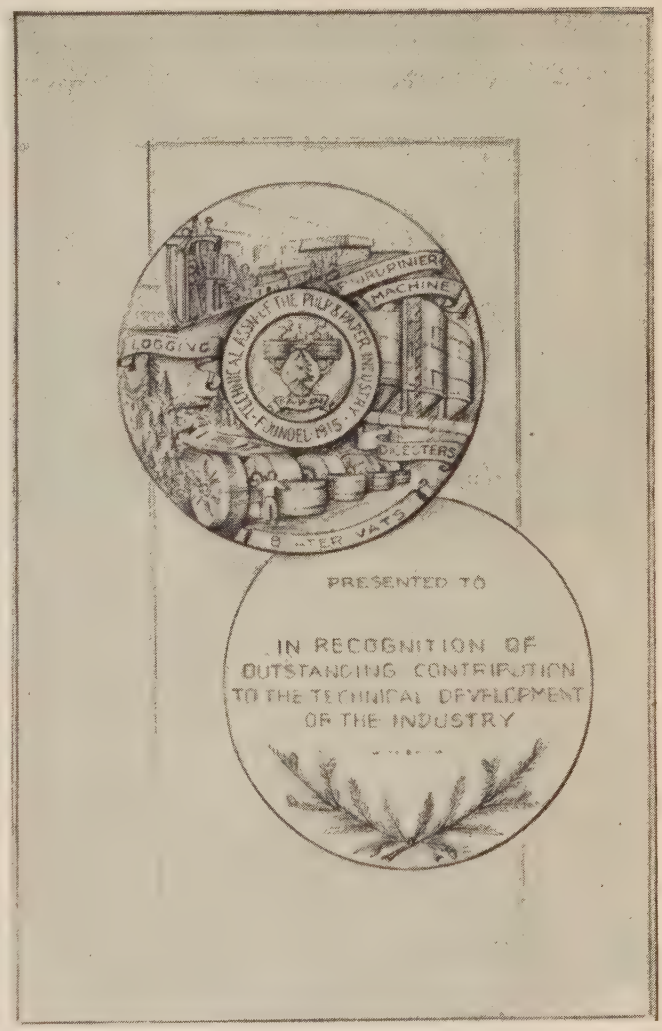
The Coating Conference is being sponsored jointly by the TAPPI Coating Committee and the New England Section, R. J. Proctor, Fitchburg Paper Co., Fitchburg, Mass., Chairman.

George H. Tomlinson Receives the TAPPI Medal

The nineteenth TAPPI Medal was presented to George H. Tomlinson, Vice-President of the Howard Smith Paper Mills, Montreal, P. Q., at the annual luncheon of the Technical Association, held on Thursday, February 22, 1951. J. N. Stephenson of the *Pulp and Paper Magazine of Canada*, Gardenvale, P. Q., made the official presentation on behalf of the Executive Committee of the Association. The remarks of Messrs. Stephenson and Tomlinson follow:

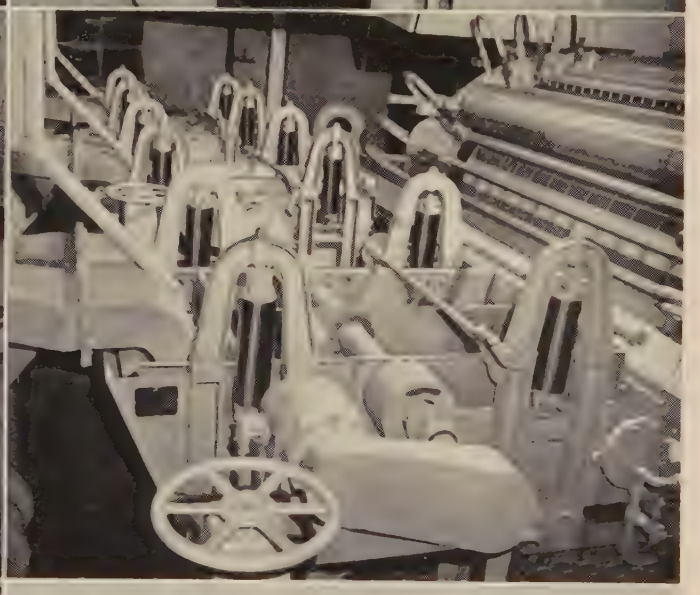
Presentation Remarks by Mr. Stephenson

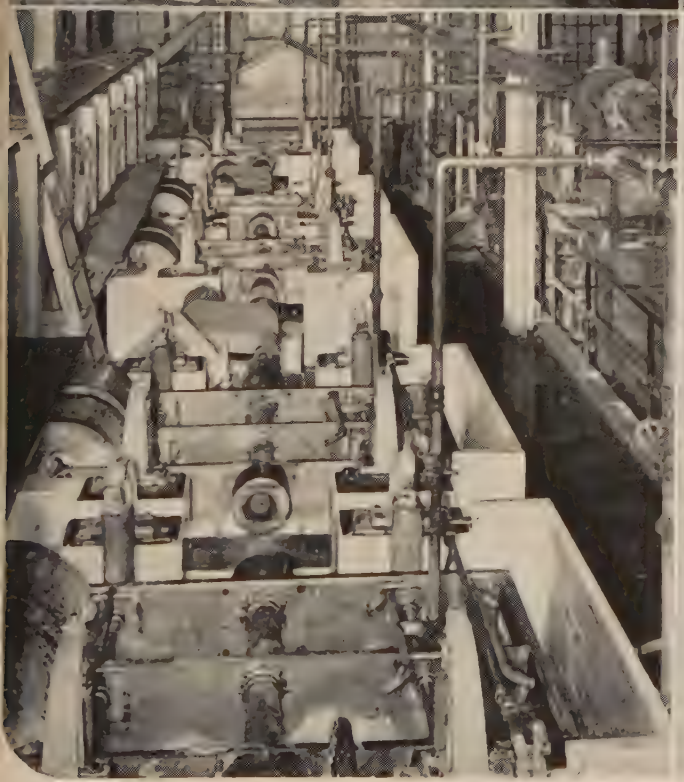
For the second time in the history of the TAPPI Medal, it has been the privilege of a medalist to make the presentation. Ten years ago, Ernst Mahler invested Otto Kress with this award. The recipient this year is George Herbert Tomlinson, Vice-President and Director of Howard Smith Paper Mills Ltd. and for many years the very active head of their extensive research program. In 1901, one year before I left the end of a finger in the calender stack at the B. D. Rising Paper Co.'s mill, Mr. Tomlinson, having graduated from



The TAPPI Medal

The 36th Annual Luncheon of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 22, 1951





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Upper Canada College and Trinity University, Toronto, joined the Lake Superior Power Co. at Sault Ste. Marie. This Company had been organized a very few years before by that remarkable man, the late Francis H. Clergue. Among his many undertakings Mr. Clergue included a sulphite mill, closely integrated with a plant for burning nickeliferous pyrrhotite in an atmosphere of oxygen, employing Herreshoff furnaces for the purpose, and also a plant for producing liquid sulphur dioxide. The oxygen required was obtained by a process involving the liquefaction of air. Mr. Tomlinson was fortunate in being assigned to the job of control chemist in connection with this unusual project, which was so far in advance of its time that only the sulphite mill survived. I once spent a very interesting half hour hearing the story of his experiences at Sault Ste. Marie. During the autumn of 1903 the Lake Superior Power Company failed, and Mr. Tomlinson went to Chicago, where the infusion of a bit of physical chemistry acted like the famous monkey glands in activating the business of the Liquid Carbonic Company.

It was Mr. Tomlinson's next project that established his success in the practical application of scientific research. In 1908, he undertook the development of a process for the production of ethyl alcohol from wood waste. Plants were established and operated at Georgetown, S. C., and Fullerton, La. I remember referring to his process in my lectures at the University of Maine in 1913 or 1914. He came back to his native Canada in 1914, at the outbreak of war. Unfortunately his health had been impaired as a result of overwork while living in the South. This condition necessitated a curtailment in his activities over the next few years. However, during the war he was engaged for a period in the manufacture of shell components, as well as serving in various advisory capacities. Early in 1919 he accepted a position as Research Director with the Riordon Co. at Hawkesbury. During the following year the Riordon Co. failed, and it was then that Mr. Tomlinson entered the employ of Howard Smith Paper Mills Ltd. as Technical Director, recently completing 30 years of service with that concern. Since being connected with Howard Smith Paper Mills, he has been the inventor of several commercially important patented processes. His greatest contributions to the industry have been in the field of the manufacture of chemical pulps, by applying research and sound engineering principles toward the better utilization of wood and other materials.

Having come to know Mr. Tomlinson quite intimately during the past quarter century there are many things I have known about that would take too long to tell, but a few outstanding contributions should be mentioned.

Mr. Tomlinson designed and was responsible for the early operation of a soda mill in Cornwall, Ont., which, in 1927, operated with a combination of such now well-established process stages as continuous vacuum brownstock washing, multiple-stage evaporation, stationary recovery furnaces, electrostatic precipitation, continuous causticization, and lime sludge reburning. He also pioneered in the continuous multiple-stage bleaching of pulp employing chlorine as the initial stage, such processing being of importance in the case of difficultly bleachable kraft pulps, and his first plant of this type has been operating since 1929.

His best known development in the alkaline processes is the B & W-Tomlinson recovery furnace, through which a large percentage of the world's kraft liquor is now being processed.

In the sulphite pulping field, Mr. Tomlinson experimented with such developments as indirect cooking with acid circulation, acid-preheating, and blow-heat and sulphur recovery.

In the field of lignin research, together with a number of associates, Mr. Tomlinson developed plastic materials, of which Arborite has become well known, and developed a plant to manufacture vanillin, an early use of which was in flavoring the ice cream at the C.P.P.A. banquet in 1937.

Realizing the difficulties inherent in the evaporation and combustion of normal calcium-base sulphite waste liquor he experimented with other bases and found that magnesium-base waste liquor could be readily neutralized with recovered magnesium oxide, evaporated with a minimum of corrosion, and without scale, and the resultant liquor incinerated to yield recoverable heat, sulphur dioxide, and a pure chemically reactive magnesium oxide. This latter, by suspension in water, can then be continuously used for absorbing the regenerated sulphur dioxide, thus obtaining fresh cooking acid and forming a cyclic process. In cooperation with the Babcock & Wilcox Co. a semicommercial scale pilot plant using the liquor from one 10-ton digester was built in Cornwall in 1936–1937. Entry of Canada into the war in 1939 delayed plans for full-scale commercial development. Arrangements were made for pooling of scientific information with the Weyerhaeuser Timber Co., who were independently carrying on parallel research and eventually resulted in the establishment of a full-scale plant at Longview.

In 1948 Mr. Tomlinson was awarded the Canada medal of the Society of Chemical Industry of England for his outstanding contributions to the Chemical Industry in Canada. In 1946 he received the honorary degree of Doctor of Civil Laws from the University of Bishop's College, which he has served as a trustee for many years. He is also a governor of the Ontario Research Foundation and a life governor of the Montreal General Hospital.

In view of these outstanding accomplishments, it seems hardly necessary to ask for a vote confirming the wisdom of the Executive Committee in awarding the Medal of the Technical Session of the Pulp and Paper Industry to George Herbert Tomlinson, which is given, as the inscription reads: "In Recognition of Outstanding Contributions to the Technical Development of the Industry."

George, my good friend, it is an honor and a great pleasure to present you with the TAPPI Medal—1950.

Response by Mr. Tomlinson

In accepting the medal which I have just received, I fully appreciate the very great honor it confers upon its recipient, and I wish to express my most sincere thanks to the members of the Executive Committee of TAPPI for having favored me with this highly coveted award. I also wish to thank Mr. Stephenson for making the presentation and for his complimentary references to my work.

In my case the honor seems all the more significant in view of my Canadian birth, residence, and citzenship, inasmuch as I am the first Canadian qualifying in all of these three categories to receive the medal.

It is also a coincidence that my industrial career began in 1901, just 50 years ago. My first job was in a plant being erected at Sault Ste. Marie for making liquid sulphur dioxide for use in a sulphite mill, with my duties extending into the latter. Inasmuch as I am receiving the medal at this time, I can therefore properly look upon this year as the Golden Anniversary of my connection with the pulp and paper industry for more reasons than one.

Fifty years is a long period in the span of life, but nevertheless it is a very short period in the history of papermaking, the beginning of which in its most primitive form is obscure, but probably dating back for about 2000 years. Nevertheless, for many centuries, the manufacture of paper was little more than a handicraft, with rags as the usual raw material. During the 19th century, however, a number of inventions occurred which laid the foundation for the pulp and paper industry as we know it today. I refer particularly to the invention of the paper machine which provided the means for the mass production of paper, and the several processes for pulping wood which had the effect of providing an inexhaustible source of the necessary fiber. Since then and within the period of my career, I have been privileged to see the pulp

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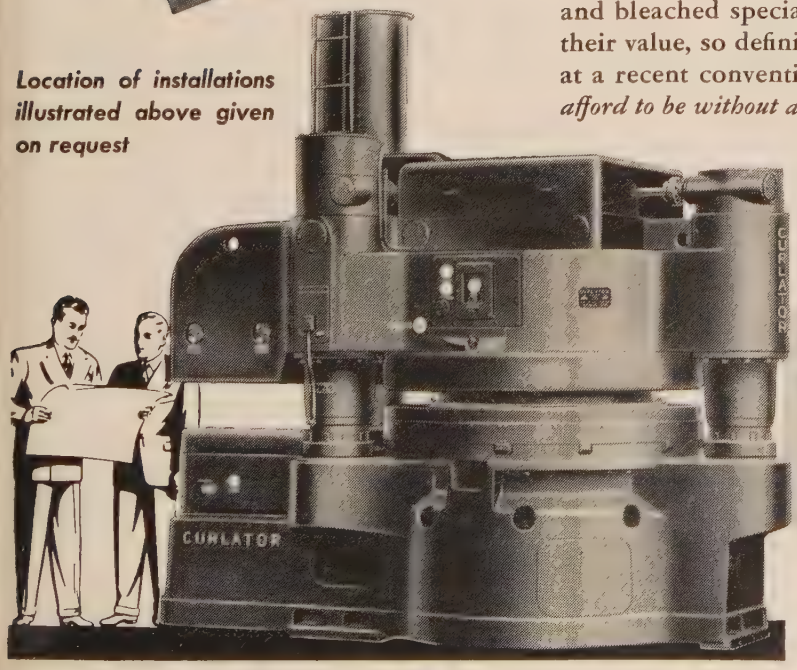

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and paper industry develop from what might be described as an infant to that of being a giant. In my country the manufacture of pulp and paper has become our greatest and most important industry, while in yours it is certainly one of the most important.

This spectacular growth in the use of paper can be attributed to our expanding civilization, to our improved standard of living now extended to an ever-increasing percentage of the population, to the industrial enterprise that has made paper both abundant and cheap, combined with the development of many new uses for pulp and paper products; all reacting to create a demand for these products which appears to be almost insatiable.

During this same period it has also been my privilege to witness and to some extent participate in the coincident almost fantastic technical advance which has accelerated the developments I have mentioned. This technical advance, to which so many have contributed, has been greatly stimulated through the activities of your great Association, together with those of similar Associations in other countries, including our own Technical Section in Canada. It is well for us to remember, however, that so far we have done little more than to improve the tools, techniques, and processes, handed down to us from the century that went before.

Many of the improvements that have been made have been outstanding, but in the main they have come about to a much greater extent through the application of our more advanced mechanical and chemical engineering skill, rather than from the invention of anything fundamentally new. However, when we scan the condition of many of our modern mills, it would seem that it is now technically possible to approach the ultimate of efficiency in the use of labor, chemicals, power, and steam, as well as in the quality of the products being made. We, therefore, have every reason to be proud of what has been accomplished, and to some, it might even appear that there is little more to be done other than to continue striving for greater production. Such, of course, is far from being the case, and now that we are entering the second half of the century, it seems suitable on this occasion to consider briefly some of the paths for development which lie ahead.

Unquestionably the opportunities still open for improving our conventional methods of making pulp and paper, merely through the application of engineering skill, are becoming less and less. It would seem likely, however, that continuous cooking will be developed to replace batch cooking in the production of pulp. Also that better methods, and means, will be devised for controlling each step involved in the manufacture of pulp and paper to insure greater uniformity of quality, and in some cases, greater yields of the products being made. Much of the auxiliary equipment now in use can probably be improved, to insure its greater reliability, and freedom from trouble. Means will be further developed to avoid polluting the atmosphere with the obnoxious fumes and odors escaping from the alkaline pulp mills, as well as to avoid contaminating our streams and rivers with undesirable effluents. These are only some of the items that might be mentioned, but nevertheless such improvements will not fundamentally alter the present technical status of the pulp and paper industry. On the other hand, I cannot help but feel that we in our generation have been laying the foundation for another great advance, possibly equally significant as the one resulting from the inventions made in the 19th century.

In place of being principally concerned with the mechanisms for producing pulp and paper, the next advance, as I see it, will be made in the fields of forestry and chemistry.

Fifty years ago it was assumed that our natural forests were inexhaustible, and for that reason a standing tree seemingly had no appreciable value. This assumption naturally placed a premium on mass production without the need for economy in the use of the wood contained in a tree. Since then we have realized that our forests were being rapidly depleted, but so far what has been done to replenish their growth has not been sufficient to meet our rapidly increasing needs, thus leading to a shortage, except in remote regions, in the supply of wood. We have, however, improved our methods for mass production to a stage nearing perfection, but what about our efficiency in the use of wood? It is my understanding that on the average, even today, only about one third of the wood contained in a tree reaches the market in the form of a salable product. The remaining two thirds is divided between the mechanical loss and chemical shrinkage incidental to the processing of the tree into pulp and paper. Obviously, more complete utilization places a greater value on trees, thus making them more attractive as an agricultural crop without adding to the cost of making pulp and paper.

When measured in terms of pulp production, when pulp is the sole product, it would appear that our present efficiency in the use of wood is relatively satisfactory since only about 50% of the wood is cellulose, and there are always parts of the tree unsuitable for this particular use. When measured, however, in terms of our present knowledge of the chemistry and the physical properties of wood, our existing efficiency ceases to be a matter for pride, particularly in view of its growing scarcity.

It has already been demonstrated that, by properly integrating the production of the various products made from wood, practically all of the wood that grows in a forest can be profitably utilized without the need for mechanical loss.

It has also been demonstrated that all of our residual pulp mill liquors can be used to advantage for fuel purposes; which represents a comparatively recent advance, but one which should be looked upon merely as a valuable expedient, at least in part.

It has also been demonstrated that by taking advantage of these developments, and thus utilizing all of the wood that grows for some useful purpose, the value of the crop is sufficiently enhanced to permit tree farms being operated on a profitable basis. Obviously the profit would become even greater under conditions favoring a more rapid than normal growth, if and when this step can also be achieved. Furthermore, with proper management over such highly developed areas, the appalling loss normally experienced from fire and from insect attack should be greatly reduced. Tree farming could also serve as a means for controlling floods and preventing erosion in many regions where these conditions are a source of trouble.

We also know that the potential of scientific research is unlimited, when adequately employed, and fortunately its employment in the pulp and paper industry is now being greatly accelerated after many years of neglect. The outcome of this greater research activity is a matter merely for speculation, but unquestionably cellulose is destined to play an ever increasingly important role in our industrial life, not only in paper, but in many other products as well.

The period in which we are living frequently has been called the Cellulose Age. At this time it might appear fantastic to suggest that we are now approaching a period which some day may be referred to as the Lignin Age. Nevertheless, in view of our present knowledge of pulp mill residual liquors, it would seem likely that a new chemical industry will emerge, based upon the utilization of this vast storehouse of organic raw material in which lignin is such an important constituent.

Nor can we overlook the possibility of some entirely new pulping process being invented for the purpose of fractionating the various components contained in wood, and delivering these each in a more valuable and readily available form.

Without speculating further and even on the basis of what we already know, it therefore seems safe to say that the manufacture of pulp and paper is entering a new era, in which its manufacture will be but one department of a highly integrated and much greater industry, making many products both old and new from the wood being cut from the tree farms of the future.

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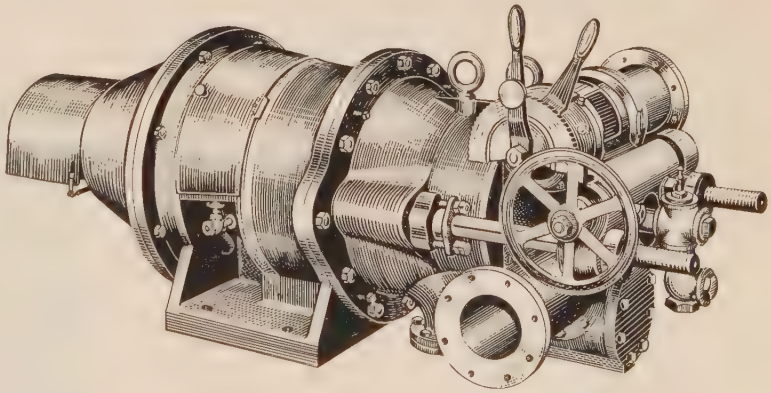

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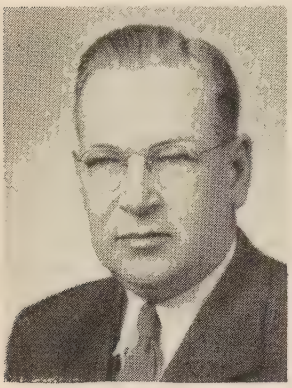
Report of the Tellers Committee

Nicholas Shoumatoff of the West Virginia Pulp and Paper Co. and Chairman of the Tellers Committee reported on the results of the mail ballot for election of Association officers and executive committeemen. His associates on the committee were Frederick Wierk, Consulting Engineer, and John H. Noble, Improved Paper Machinery Co., all of New York City. The committee reported as follows:



George H. Pringle

James R. Lientz

We, the members of the Tellers Committee, having made a canvass of the official ballot for officers and members of the Executive Committee for 1951 of the Technical Association of the Pulp and Paper Industry, have found that the following have received a majority of the 898 votes cast:

President: Kenneth P. Geohegan, Howard Paper Mills, Inc., Dayton, Ohio.

Vice-President: George H. Pringle, Mead Corp., Chillicothe, Ohio.

Executive Committeemen (to serve three years):
William F. Hathaway, Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich.
Walter F. Holzer, Crown Zellerbach Corp., Camas, Wash.
Ward D. Harrison, Riegel Paper Corp., Milford, N. J.
Richard P. Price, Hammermill Paper Co., Erie, Pa.

Executive Committeeman (to serve one year):
James R. Lientz, Union Bag & Paper Corp., Savannah, Ga.

TAPPI 1951 Executive Committee

As reported by the Tellers Committee, Kenneth P. Geohegan and George H. Pringle were elected President and Vice-President, respectively, of the Technical Association. James R. Lientz was elected to fill the unexpired term of Mr. Pringle as a member of the Executive Committee. William F. Hathaway, Walter F. Holzer, and Ward D. Harrison were elected to three-year terms and Richard P. Price was re-elected to serve a three-year term as member of the Executive Committee.

Kenneth P. Geohegan is Vice-President of the Howard Paper Mills, Inc., Dayton, Ohio. Mr. Geohegan was born in Cincinnati, Ohio, in 1893, graduated as a chemist from the University of Cincinnati in 1915, and received his master's degree from Cornell University in 1924. Prior to joining the Aetna Paper Co., in 1925 (Aetna is now a division of the Howard Paper Mills) he was employed by the Procter and Gamble Co., the American Oak Leather Co., U. S. Army Ordnance Dept., the Roessler and Hasslacher Co., The Richardson Co., and Georgia School of Technology. In TAPPI he has had an active career from the start, serving on various committees and as a Chairman of the Ohio Section. As Chairman of the Local Sections Committee of the Executive Committee, Mr. Geohegan did much to establish all sections as real working groups.

George H. Pringle, Asst. Chief Engineer of the Mead Corp., Chillicothe, Ohio, was born in Pictou, N. S., in 1903 and graduated from McGill University as a mechanical engineer in 1926. From 1926 to 1927 he was employed by the Canada Paper Co., at Windsor Mills, P. Q., as a junior engineer. He joined the Mead organization in 1927 as Division Engineer. Mr. Pringle has taken a very active part in the advancement of the reorganized TAPPI Engineering Division, of which he is General Chairman.

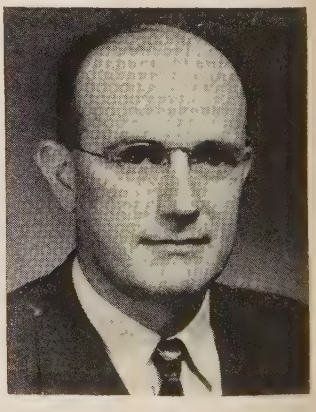
James R. Lientz, General Superintendent of the Pulp and Paper Division of the Union Bag & Paper Corp., Savannah, Ga., was born in 1913 at Los Angeles, Calif. In 1937 he received his master's degree in chemical engineering from the University of Michigan. From 1933 to 1940 and in 1942–1943 he was a chemical engineer for the Swenson Evaporator Co. In 1940–1942 and since 1943 he has been with the Union Bag. In TAPPI he is Chairman of the Chemical Engineering Committee and has done much to revitalize this important group. At present the Committee is making a very important study of the causes of corrosion in alkaline pulping digesters.

William F. Hathaway is Technical Superintendent of the Beater Room and Bleach Plant of the Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich. Mr. Hathaway was born in Cincinnati, Ohio, in 1907 and graduated from the University of Maine in 1932 as a chemical engineer. He joined the KVP organization in 1932 as a chemist although he had previously worked for this Company while attending Kalamazoo College. In TAPPI he has been active in committee work and was Chairman of the Kalamazoo Valley Section.

Walter F. Holzer, Asst. Director of Research for the Crown Zellerbach Corp., Camas, Wash., was born in 1908 at Portland, Ore. In 1929 he graduated from Reed College as a chemist and received his Ph.D. from The Institute of Paper Chemistry in 1934. He has been with the Crown Zellerbach Corp. since 1929 except for brief periods at the Rhinelander Paper Co. and the Fox River Paper Co. In TAPPI he has been an active committeeman and was Chairman of the Pacific Section.

Ward D. Harrison, Vice-President of the Riegel Paper Corp., Milford, N. J., was born in 1909 at Blue Earth, Minn., and graduated as a chemical engineer from Iowa State College in 1932. In 1936 he received his doctorate from The Institute of Paper Chemistry. In addition to the Riegel Paper Corp., he has been employed by the Crown Zellerbach Corp., Northwest Paper Co., and the Ecusta Paper Co. In TAPPI he is Chairman of the Pulp Purification Committee and is directing the preparation of what will be an excellent book on pulp bleaching.

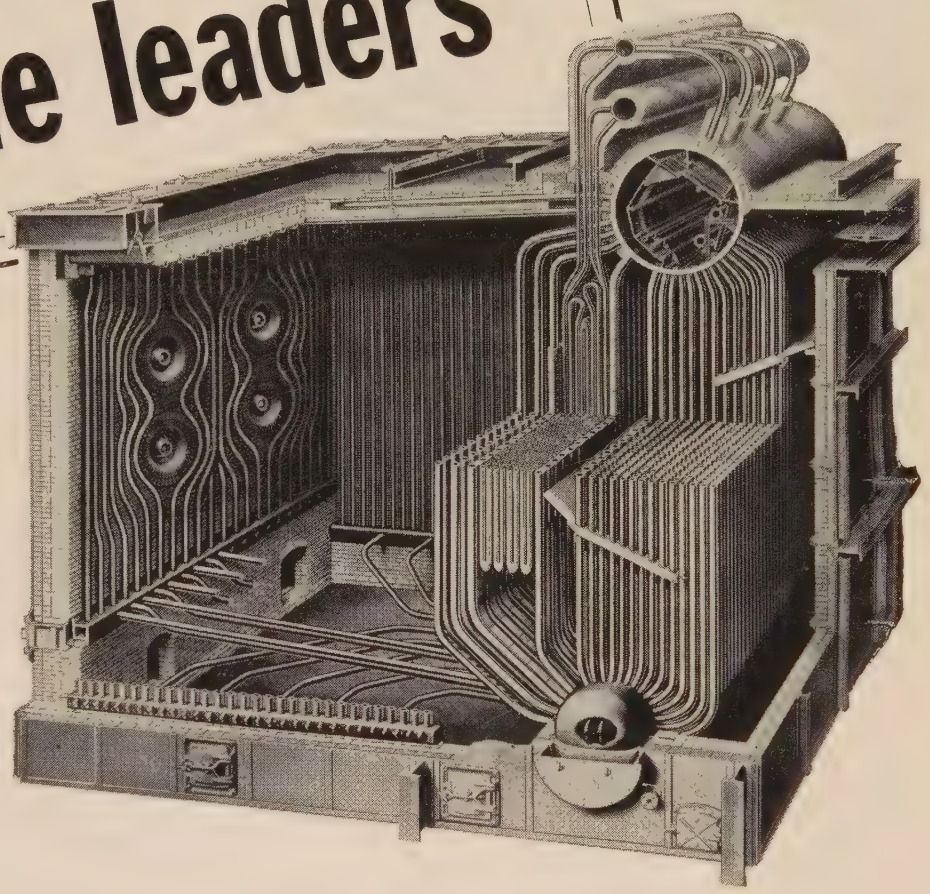
William F. Hathaway



Walter F. Holzer

Richard P. Price, Vice-President and General Superintendent of the Hammermill Paper Co., Erie, Pa., was born at Whitford, Pa., in 1902, and graduated from the Massachusetts Institute of Technology in 1926. He joined the Hammermill organization in 1926 and is now also Vice-President of the Grays Harbor Pulp and Paper Co., at Hoquiam, Wash.

Choice of the leaders



A partial list of pulp and paper companies that have purchased C-E Vertical-Unit Boilers for one or more mills.

•

Albemarle Paper Mfg. Co.
Allied Paper Mills
Brompton Pulp & Paper Co., Ltd.
The Brown Company
Canadian International Paper Co., Ltd.
Central Fibre Products Co.
Chemical Paper Mfg. Co.
Chesapeake Corporation
Consolidated Paper Corp., Ltd.
Container Corp. of America
Dryden Paper Co., Ltd.
Eddy Paper Corp.
Fraser Companies, Ltd.
The Gardner Board & Carton Co.
Great Lakes Paper Co., Ltd.
Gulf States Paper Corp.
Hammermill Paper Company
International Paper Co.
Kalamazoo Vegetable Parchment Co.
Kimberly-Clark Corporation
Macon Kraft Corporation
Marathon Paper Mills of Canada, Ltd.
Minnesota & Ontario Paper Co.
Nanaimo Sulphate Pulp Ltd.
National Container Corporation
Nekoosa-Edwards Paper Co.
The Northwest Paper Company
Riegel Carolina Corp.
St. Regis Paper Company
Scott Paper Company
Southern Kraft Division,
International Paper Co.
Southern Paperboard Corp.
Southland Paper Mills, Inc.
United Board & Carton Co.
S. D. Warren Company

In all important paper producing areas of the United States and Canada you will find C-E Vertical-Unit Boilers in the plants of leading pulp and paper manufacturers. A partial list of the companies that have purchased VU Units appears at the left. In many cases these companies have placed repeat orders. B-442

COMBUSTION ENGINEERING—SUPERHEATER, INC.

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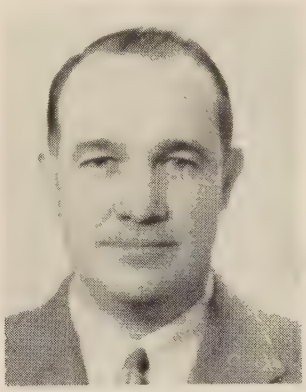
Report of the Secretary

A rapid growth of the Technical Association of the Pulp and Paper Industry continued through 1950. The six regional meetings, in addition to the annual meeting, were unusually well attended and were successful in attaining their objectives.

Membership

There were 540 individual members elected in 1950, 217 resigned or were dropped from the membership. On December 31, 1950, the total individual membership was 4268.

Ward D. Harrison



Richard P. Price

There were 14 corporate members elected. Three corporate members resigned.

There were 9 sustaining members elected. Five sustaining members resigned.

The corporate membership on December 31, 1950, was 220, and the sustaining membership was 190.

The following companies became corporate members in 1950:

Association Technique De L'Industrie Papeterie, Paris, France
Austrian Paper & Pulp Association, Vienna, Austria
Ballapur Paper & Straw Board Mills Ltd., The, Nagpur, India
Bowater's Newfoundland Pulp & Paper Mills Ltd., Corner Brook, Nfld.
Cia. Industrial de Atenquique, S. A., Atenquique, Mexico
Feldmuhle, Papier und Zellstoffwerke A/G Bielefeld, Ger. British Zone.
Forest Products Research Laboratory, Bratislava, Czechoslovakia
MacMillan, H. R., Export Co., Ltd., Pulp Div., Nanaimo, B. C.
Mitsubishi Paper Mills Ltd., Tokyo, Japan
Nippon Art Paper Mfg. Co. Ltd., Tokyo, Japan
Sanyo Pulp Co., Ltd., Tokyo, Japan
Tohoku Pulp Co., Ltd., Tokyo, Japan
Tomakomai Paper Mfg. Co., Ltd., Tokyo, Japan
Warren, S. D., Co., Cumberland Mills, Me.

The following companies became sustaining members in 1950:

Louis Allis Co., Milwaukee, Wis.
Gold Fields American Development Co. Ltd., New York, N. Y.
Harris-Seybold Co., Cleveland, Ohio
Hauser-Stander Tank Co., Cincinnati, Ohio
Hubinger Co., Keokuk, Iowa
New England Lime Co., Adams, Mass.
Spencer Chemical Co., Kansas City 6, Mo.
Tremont Lumber Co., Chicago, Ill.
Western Precipitation Corp., Los Angeles, Calif.

Necrology

The Association lost the following members through death:

James H. Allen, St. Regis Paper Co., Pensacola, Fla.
Carl E. Apelgren, St. Regis Paper Co., Oswego, N. Y.
E. F. Bearce, Chillicothe Paper Co., Chillicothe, Ohio
Jules J. Becker, Harving Paper Co., Hyde Park, N. Y.
N. H. Carpenter, Jr., Muskingum Fiber Products Co., Coshocton, Ohio
A. Fred Crossman, Lindsay Wire Weaving Co., Cleveland, Ohio
L. S. Dixon, Consulting Engineer, Bangor, Me.
Edouardo O. Frigerio, La Papelera Argentina, Buenos Aires, Argentina
H. C. Fleischer, Swan Mill Paper Co. Ltd., London, England
Merton S. Fogerty, Sutherland Paper Co., Kalamazoo, Mich.
Samuel L. Foster, Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich.
John Graff, Institute of Paper Chemistry, Appleton, Wis.
Thomas M. Gillespie, Lockport Felt Co., Kalamazoo, Mich.
Andrew H. Gilmour, C. H. Norton Co., N. Westchester, Conn.
Ralph A. Hayward, Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich.
Walter H. Hermann, The Hermann Mfg. Co., Lancaster, Ohio
Edouard, Hery, Editor, *Le Papier*, Paris, France
E. A. Holland, Holland Advertising Agency, Philadelphia, Pa.
S. Richard Holmes, Gardner Board & Carton Co., Middletown, Ohio
Alvin H. Johnson, Consulting Engineer, New York, N. Y.
F. W. Johnson, Rhinelander Paper Co., Rhinelander, Wis.
Louis S. Keyser, Rayonier, Inc., Shelton, Wash.
James C. Lowe, Oliver United Filters Co., Chicago, Ill.
W. J. McCarthy, News Syndicate Co., New York, N. Y.
Albert G. Milham, Watervliet Paper Co., Watervliet, Mich.
James Murray, Martin Cantine Co., Saugerties, N. Y.
Charles N. Neely, Plaskon Div., Libbey-Owens-Ford Glass Co., Toledo, Ohio
Harry T. Newman, New York City Central Testing Laboratory, New York, N. Y.
Olof Olsson, Mo och Domsjo A/B, Husum, Sweden
W. H. Savery, Retired, Wilmington, Del.
Harry W. Schwartz, Robertson Paper Box Co., Inc., Montville, Conn.
E. A. Shallcross, Sr., Consulting Chemical Engr., Philadelphia, Pa.
C. B. Smith, Huron Milling Co., Kalamazoo, Mich.
Killey E. Terry, S. D. Warren Co., Cumberland Mills, Me.
L. G. Vande Bogart, Crane Co., Chicago, Ill.
J. B. Venturini, Cameron Machine Co., Brooklyn, N. Y.
George H. Young, Midwest-Fulton Machine Co., Dayton, Ohio

Meetings of the Association

The Association, in 1950, returned to its practice of holding an annual meeting and several functional meetings. Six of the latter were held.

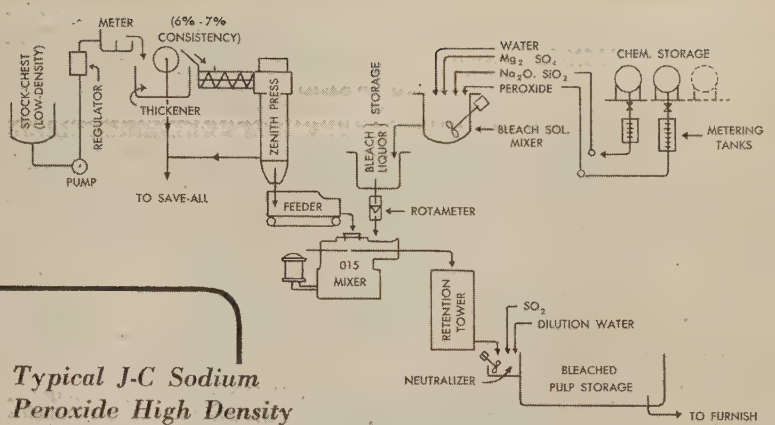
1950 Annual Meeting

The annual meeting was held at the Commodore Hotel in New York City on February 20–23, 1950. More than 1500 attended. Eighty-three papers were presented. The annual luncheon was featured by an address by Joseph E. Atchison of the Economic Cooperation Administration on the Marshall Plan and the Pulp and Paper Industry in Europe, and by the presentation of the TAPPI Medal to George H. Mead by Reuben B. Robertson.

Fundamental Research Conference

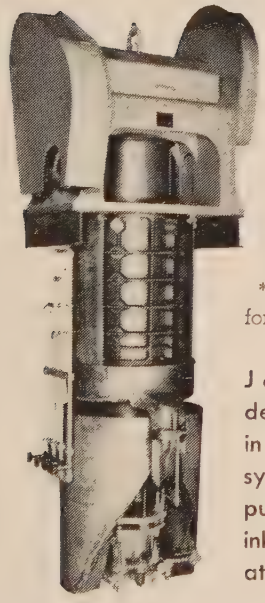
A Fundamental Research Conference was held at the Chateau-Frontenac Hotel, Quebec, P. Q., on May 29–31, 1950. This was a joint meeting with the Technical Section of the Canadian Pulp and Paper Association and was devoted to a consideration of "The Effect of Fiber Characteristics on Paper and Papermaking Properties." The general chairmen of this meeting were Harry F. Lewis of The Institute of Paper Chemistry, Appleton, Wis., and W. Gallay of the E. B. Eddy Co., Hull, P. Q. In addition to participants of these two associations there were representatives of the British Paper and Board Association and the Swedish Forest Products Laboratory. This meeting was of considerable significance since it was the first comprehensive attempt made to consider the basic fundamentals of stock preparation and paper formation. Hitherto this subject has been treated in terms of practical operation. The symposia included the following subjects: "The Individual Fiber Properties Related to Paper Making," "Strength and Mechanical Properties," "Surface Properties and Measurements," "Fiber-Fiber Bonding," and "The Effect of Chemical Composition of Fibers on Papermaking Properties." The papers presented at this conference were published in the August, 1950, and September, 1950, issues of *Tappi* and *Pulp and Paper of Canada*.

Jackson and Church — HIGH DENSITY SYSTEM



Typical J-C Sodium Peroxide High Density Bleaching System

USES *NO MORE* PEROXIDE TO BLEACH *HIGHER* TONNAGE TO *SAME* BRIGHTNESS or *SAME* TONNAGE TO *HIGHER* BRIGHTNESS



* Patents applied for J & C copyright

J & C Zenith Press designed for use in high density systems, and in pulp washing, de-inking and storage at high density.

For engineering assistance and actual mill performance data, write Dept. D

The J&C High Density System makes possible bleach consumption savings up to 25%.

HERE ARE ADDITIONAL ADVANTAGES:

High density—40% or higher
Continuous operation
Fully automatic operation
Selective pressure control
Product of uniform consistency
Moderate first cost
Extremely rugged construction
Available in corrosion resistant alloys
Low power requirement
Minimum floor space
Aids good housekeeping

JACKSON & CHURCH COMPANY · SAGINAW, MICHIGAN

Testing Conference

The Testing Division conducted its second conference at the Recreation Building of the Eastman Kodak Co., in Rochester, N. Y., on September 13–15, 1950. The first conference was held in 1948 at the Mellon Institute for Industrial Research in Pittsburgh, Pa. James d'A. Clark, Consultant, Longview, Wash., and General Chairman of the Testing Division, was general chairman of the conference. The meeting was held in workshop style during which the Pulp Testing, Microscopy, Optical Properties, Nonfibrous Materials Testing, Packaging Materials Testing, Graphic Arts, Wax Testing, Paper Testing, and Chemical Methods Committees reviewed the progress of their work and laid the groundwork for the development of new testing procedures. The meeting was featured by a visit to the two paper mills and the film manufacturing departments of the Eastman Kodak Co. The Association was indebted to the courtesies of the Eastman Kodak Co., who provided exceptionally fine meeting facilities and to G. T. Lane, Asst. Manager of the Kodak Park Works, and Milton Fillius of the Company who were responsible for obtaining these privileges for the Association.

Fifth Engineering Conference

The Fifth Engineering Conference of the Pulp and Paper Industry was held at the Netherland Plaza Hotel in Cincinnati, Ohio, on October 2–5, 1950. This meeting followed similar conferences at Milwaukee, Philadelphia, Buffalo, and Boston. All of these conferences have been unusually successful, especially in attracting the attendance of the principal plant engineers of the industry in the United States and Canada and in the quality of the presentations sponsored by the Mill Design and Economic Aspects, Hydraulics, Engineering Research and Machine Design, Materials Handling, Mill Maintenance and Materials, Data Sheets, Drying and Ventilating, and Chemical Engineering Committees. Following the meeting plant visits were made in Cincinnati and the Miami Valley. George H. Pringle, Asst. Chief Engineer of the Mead Corp., was general chairman of the conference. Ragnar Soderquist of Stora Kopparberg A/B, President of the Swedish Association of Pulp and Paper Engineers, attended this meeting and extended an invitation to TAPPI members to attend the Association meetings in Sweden. Tany Agronin of Shartle Bros. Machine Co., Middletown, Ohio, was chairman of the Local Arrangements Committee which was sponsored by the Ohio Section of the Association, Don Goodman of the Sorg Paper Co., Middletown, Ohio, Chairman.

Plastics Conference

A Paper-Plastics Conference was sponsored by the Plastics Committee at the New York State College of Forestry, Syracuse, N. Y., on October 19–20, 1950. E. C. Jahn of the N. Y. State College of Forestry and Chairman of the Plastics Committee was general chairman of the conference. The conference featured symposia on "Properties of Plastics in Relation to Paper Making," "Beater Addition Fundamentals," "Cellulose-Accessibility and Properties Relating to Plastics," and "Plastic Coating Fundamentals."

Alkaline Pulping Conference

The Alkaline Pulping Committee sponsored a conference at the George Washington Hotel, Jacksonville, Fla., on October 25–27, 1950. Henry Vranian of the Chesapeake Corp. of Va. and Chairman of the Committee was general chairman of the conference. Robert R. Fuller of the Gulf States Paper Co., Tuscaloosa, Ala., was Chairman of the Program Committee, E. A. Harper of the Hudson Pulp and Paper Co., Palatka, Fla., and Karl M. Guest of the National Container Corp., Jacksonville, Fla., were in charge of local arrangements. Frank Winchell of the Jacksonville Tourist and Convention Bureau assisted the Local Arrangements Committee. The conference featured symposia on Causticization and Lime Burning. Following the meeting visits were made to University of Florida and Gainesville and the Hudson Pulp and Paper Co. mill at Palatka on October 27. In the evening the Noble & Wood Machine Co., Hoosick Falls, N. Y., was host to the convention at a get-together party and dinner at the Sportsman's Lodge, Welaka, Fla.

Fibrous Agricultural Residues Conference

The Fibrous Agricultural Residues Committee sponsored a conference at the Northern Regional Research Laboratory, Peoria, Ill., on November 12–13, 1950. S. I. Aronovsky of the Laboratory and Chairman of the Committee was general chairman of the conference. This conference which features the utilization of straw and other agricultural products for paper making was well attended by men from the midwest strawboard mills. Following the meeting visits were made to the Pabst Brewery in Peoria and the Keystone Steel & Wire Co. plant in Bartonville, Ill.

Publication of the Association, Tappi

The new Association magazine *Tappi* completed its second year of publication in December, 1950. This magazine continued as a medium of publication of the papers presented at all of the Association meetings, the record of Association activities, a number of special and contributed articles and features. The papers presented at the Fundamental Research Conference at Quebec were printed in complete sequence and separate reprints of the collective papers were made. It has been interesting to note the number of papers of which reprints are made for the authors. In many cases the reprint order has been large, reflecting thereby the large number of individuals, presumably nonmembers, who eventually receive them.

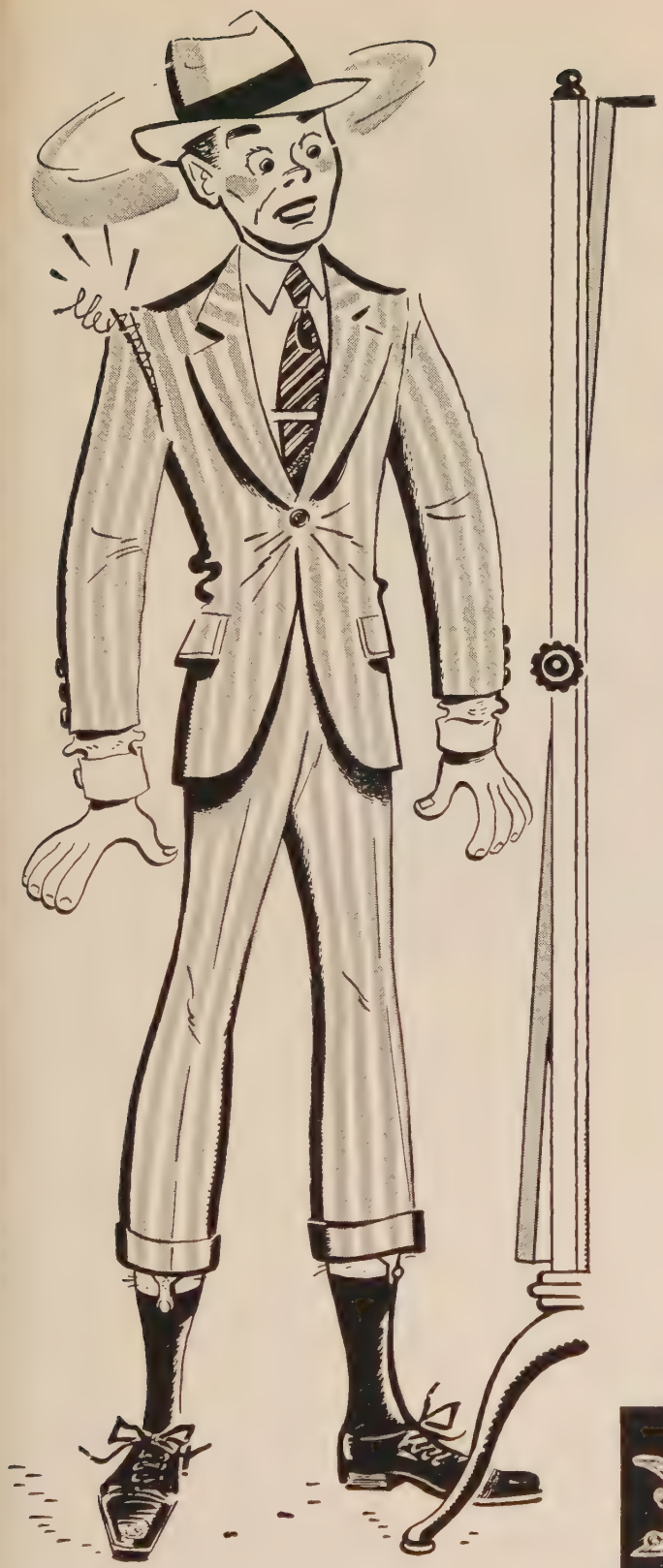
It has been gratifying to note that the quality of the papers published in *Tappi* has remained high. From time to time individual members have wondered how long this high quality could be maintained. It has been excellent to date and the future prospects appear to be good. The magazine has endeavored to offer a strictly technical service to the industry and, since it is assumed that most of our members read one or more trade papers for the current news of the industry, *Tappi* has limited itself to the publication of brief and what might be called supplementary news items of special interest and value to technical men and other mill operators. The impact of *Tappi* on the trade press has been noticeable in certain details, some of which have been improvements. Its influence on the Association committees and local sections has been noteworthy. It is hoped that as time goes on more individual members will have the urge to prepare articles or items for publication. To be fully effective the magazine should be the publication of any member who has some knowledge that he would like to share with his fellow members and the industry. The advantage to an individual of being favorably known is very great.

Bibliography of Paper Making

The Bibliography of Paper Making and U. S. Patents for 1949 was prepared by Clarence J. West, Chairman of the Bibliography Committee, and published during 1950. Dr. West now has in preparation a collective bibliography covering the period 1946 to 1950. This will be issued in 1951.

TAPPI Standards

Two new tentative standards were approved during the year. Two tentative standards were submitted to the active membership and approved by letter ballot. Two suggested methods were advanced to tentative standards. At the end of the year four submissions were under consideration by the Standards Committee. The book of TAPPI Standards is



Not everybody takes a "Regular"

As a matter of fact, some men can't find a really perfect fit unless they have their suits tailor-made.

It's that way with the supplies you buy, too. For instance, we have a complete line of standard starches and other corn products for paper mill use; but we are *also* set up to provide you with any *special* formula or product, *tailor-made* to your specifications.

And . . . standard or special . . . you'll want to buy from a company like Anheuser-Busch, whose reputation for products of highest quality, uniformity and dependability is as dominant in the paper industry as it is with retailers and consumers all over the world.

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now comprised of 50 tentative standards and 124 official standards. The Testing Conference held at Syracuse was a stimulus to the difficult work of the committees of the Testing Division. It is expected that a number of the tests being considered will reach the tentative standard or the suggested method status in the near future.

Routine Control Methods

In April the Association published in loose-leaf form a series of 157 Routine Control Methods. These methods represent testing procedures in actual use in pulp and paper mills throughout the country. Although they are not Association standards many of them may become suggested methods or tentative standards at some time in the future.

TAPPI Data Sheets

The Data Sheets Committee in the Engineering Division was active during the past year in accumulating and screening data considered to be of permanent value. A number of sheets prepared during the year will be published early in 1951.

Monographs

Two monographs in the Coated Paper Series went to the printer during the latter part of 1950 and should be ready for distribution this winter or early spring. These deal with "Coated Paper Machinery" and "Adhesives for Paper Coatings." The groundwork for a monograph on "Coated Paper Raw Stock" will be prepared at the Coating Conference to be held in Boston in April, 1951.

TAPPI Medal Award

The 1950 TAPPI Medal was presented to George H. Mead of the Mead Corp., Chillicothe, Ohio.

TAPPI Fibrary

Work continued during the year on the establishment of the TAPPI Fibrary. This is located at The Institute of Paper Chemistry and consists of samples of fibers of known history which are available to microscopists who may need them to compare fibers in samples of unknowns. A catalog of the Fibrary was printed in the February, 1951, issue of *Tappi*.

Employment

The Employment Service Column published in *Tappi* has proved to be very effective. The Association has provided an employment service without charge to any company or individual for many years. Since this service was started in *Tappi* many members and nonmembers have made use of it. With the growing shortage of competent technical men the number of jobs open have increased and are likely to continue to do so. The greatest shortage in recent months has been mill engineers of all types.

Local Sections

No new local sections were established in 1950. The Lake Erie Papermakers and Converters Association has continued to hold regular meetings at Cleveland, Ohio, and is expected to be ready to apply for a local section charter at the 1951 annual meeting of the Association.

The chairmen of the local sections elected during 1950 were as follows: *Pacific*—Robert I. Thieme, Soundview Pulp Co., Everett, Wash.; *Lake States*—H. C. Crandall, Mosinee Paper Mills Co., Mosinee, Wis.; *Delaware Valley*—A. S. Erspamer, P. H. Glatfelter Co., Spring Grove, Pa.; *Kalamazoo Valley*—James J. Harrison, Michigan Carton Co., Battle Creek, Mich.; *New England*—R. J. Proctor, Fitchburg Paper Co., Fitchburg, Mass.; *Ohio*—Don J. Goodman, Sorg Paper Co., Middletown, Ohio; *Empire State*—Henry J. Perry, *Paper Trade Journal*, New York, N. Y.; *Maine-New Hampshire*—George A. Day, Brown Co., Berlin, N. H.; *Chicago*—Albert K. Roach, Wm. H. Welsh Co., Inc., Chicago, Ill.; *Lake Erie Papermakers' and Converters' Association*—Lewis K. Burnett, Ohio Boxboard Co., Rittman, Ohio; *Papermakers and Associates of Southern California* (unaffiliated)—Claud Sharp, Los Angeles Paper Box Co., Los Angeles, Calif.

Divisions and Committees

Most of the divisions and committees of the Association were active during the past year and several sponsored national conferences of importance. The accomplishments of the committees are reflected in the meetings held, conferences sponsored, standards, routine control methods, monographs, surveys, data sheets, etc., usually resulting in publications of benefit to the industry. The following information is devoted principally to the chairmanship personnel and changes during the year:

Engineering Division: George H. Pringle, Mead Corp., Chillicothe, Ohio, general chairman. The division sponsored the Fifth Engineering Conference of the Pulp and Paper Industry, held at Cincinnati, Ohio. *Steam and Power Committee:* Charles J. Sibler, West Virginia Pulp and Paper Co., New York, N. Y., chairman. *Materials Handling Committee:* A. P. Schnyder, Ebasco Services, Inc., New York, N. Y., chairman. *Drying and Ventilating Committee:* M. L. Barker, Beckett Paper Co., Hamilton, Ohio, chairman. *Engineering Research and Machine Design Committee:* John D. Lyall, Armstrong Cork Co., Lancaster, Ohio, succeeded Philip H. Goldsmith, Pusey & Jones Corp., as chairman. Four subcommittees of this committee were established recently. *Centralized Control of Stock Systems Subcommittee:* L. A. Moore, American Coating Mills, Elkhart, Ind., chairman; *Methods for Quickly Estimating Costs of Engineering Projects Subcommittee:* H. G. Ingraham, Chas. T. Main, Inc., Boston, Mass., chairman; *Correlation of Various Types of Plastometers Subcommittee:* K. W. Brenner, Eastman Co., Rochester, N. Y., chairman; and *Standardization of Machine Parts Subcommittee:* G. E. Clink, Sandy Hill Iron & Brass Works, chairman. *Hydraulics Committee:* K. J. Mackenzie, Eastman Kodak Co., Rochester, N. Y., chairman. *Mill Design and Economic Aspects Committee:* Roland A. Packard, Lowe Paper Machinery Co., Holyoke, Mass., succeeded Alvin H. Johnson, Consultant who died just prior to the Cincinnati conference, as chairman. *Mill Maintenance and Materials Committee:* H. F. Parker, New York and Pennsylvania Co., Lock Haven, Pa., succeeded M. F. Fogerty, Sutherland Paper Co. (deceased) as chairman. *Chemical Engineering Committee:* J. R. Lientz, Union Bag & Paper Corp., Savannah, Ga., chairman. *Electrical Engineering Committee:* R. W. Foster, Champion Paper & Fibre Co., Canton, N. C., succeeded A. S. Goodrich, Hammermill Paper Co., as chairman. *Data Sheets Committee:* H. J. Perry, *Paper Trade Journal*, chairman.

Industrial Division: Werner Kaufmann, Kupfer Bros. Paper Co., Chicago, Ill., general chairman. *Vocational Education Committee:* B. E. Lauer, University of Colorado, chairman. *Nonfibrous Raw Materials Committee:* E. N. Poor, Hudson Pulp & Paper Co., Augusta, Me., chairman. *Mill Instrument Control Committee:* no chairman was appointed to succeed R. W. Porter, Fritz Publications, Inc. This committee will be reactivated when some member agrees to accept the chairmanship. *Water Committee:* A. S. Erspamer, P. H. Glatfelter Co., Spring Grove, Pa., chairman. The subcommittee chairmen were: *Analytical and Testing Methods Subcommittee:* Miss Louise E. McGrath, Booth Chemical Co., Elizabeth, N. J., chairman. *Special Projects Subcommittee:* E. N. Poor, Hudson Pulp & Paper Co., Augusta, Me., chairman; *Water Supply and Treatment Subcommittee:* S. T. Powell, Consultant, Baltimore, Md., chairman; and *White Water Treatment and Waste Disposal Subcommittee:* C. C. Porter, Southland Paper Mills, Lufkin,

Egan POLYETHYLENE COATING MACHINE

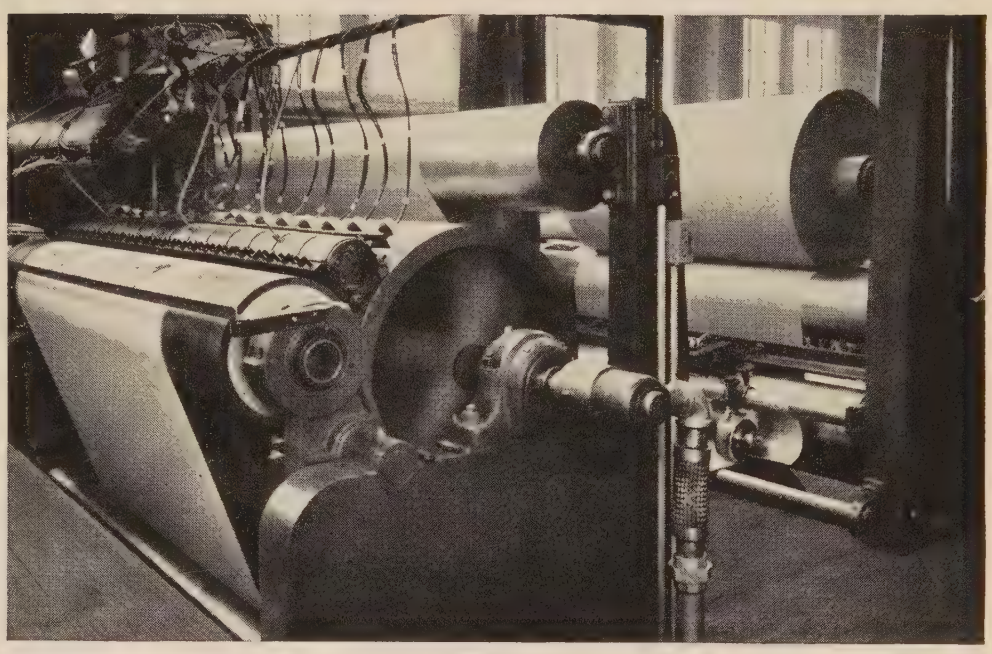

Illustration shows the Egan Polyethylene Coater in operation at the Ridgefield, New Jersey plant of the LOWE PAPER COMPANY—one of the six leading converters now using this machine.

For applying polyethylene coatings to paper or other webs—in thicknesses of .0005 to .004 inches.

Using its invaluable field experience, Frank W. Egan Company has incorporated many design improvements in their Polyethylene Coater. The new machine also includes refinements of the coating head for easier and more effective control in producing consistently good bond and for non-stop, trouble-free operation.

The Egan Polyethylene Coating Machine is ideal for a wide range of uses in the packaging field—moisture-proof bags... container linings... liquid containers.

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Tex., chairman. *Fibrous Agricultural Residues Committee:* S. I. Aronovsky, Northern Regional Research Laboratory, Peoria, Ill., chairman. The chairmen of the subcommittees were: *Procurement, Storage and Preservation Subcommittee:* H. M. Blandin, Central Fibre Products Co., Quincy, Ill.; *Raw Materials Classification Subcommittee:* S. I. Aronovsky; *Pulping Subcommittee:* J. R. Little, Hinde & Dauch Paper Co., Sandusky, Ohio, chairman; *Board and Paper Manufacture Subcommittee:* M. F. Knack, River Raisin Paper Co., Monroe, Mich., chairman; *Testing Subcommittee:* N. F. Wilson, Alton Boxboard Co., Alton, Ill., chairman. The Fibrous Agricultural Residues Committee sponsored a conference at Peoria, Ill. *Structural Fibrous Materials Committee:* John F. Campbell, Flintkote Co., Meridian, Miss., chairman. (Dr. Campbell was succeeded by E. M. Jenkins, Johns-Manville Corp., Manville, N. J., at the 1951 annual meeting of the Association.) Its subcommittee chairmen were *Raw Materials Testing:* E. M. Jenkins, chairman (J. J. Perot, Jr., Flintkote Co., Whippany, N. J., will succeed Mr. Jenkins in February, 1951) and *Finished Products Testing Subcommittee:* Emile Frederick, Jr., Celotex Corp., Marrero, La., chairman.

Converting and Consuming Division: Martin L. Downs, Thilmany Pulp & Paper Co., Kaukauna, Wis., succeeded Ralph A. Wilkins, Bird & Son, Inc., E. Walpole, Mass., as general chairman. *Containers Committee:* H. T. Barker, Bird & Son, Inc., E. Walpole, Mass., chairman. The chairman of the *Corrugated Containers Subcommittee* was F. D. Long, Container Corp. of America, Chicago, Ill. *Graphic Arts Committee:* Fred D. Elliott, Time, Inc., Springdale, Conn., succeeded R. H. Simmons, Government Printing Office, as chairman. *Wet Strength Committee:* K. W. Britt, Scott Paper Co., Chester, Pa., chairman. *Coating Committee:* J. H. Heuer, St. Regis Paper Co., Deferiet, N. Y. (Mr. Heuer is now with A.P.W. Products Co., Albany, N. Y.) succeeded Werner Kaufmann, Kupfer Bros. Paper Co., as chairman. The subcommittee chairmen were: *Adhesives Subcommittee:* Miss R. M. K. Cobb, Lowe Paper Co., Ridgefield, N. J., chairman; *Defoaming Agents Subcommittee:* W. B. Morehouse, Nopco Chemical Co., Harrison, N. J., chairman; *Starch Subcommittee:* J. G. Bullard, Corn Products Refining Co., New York, N. Y., chairman; *Wax Subcommittee:* J. D. Clark, D. L. Ward Co., Philadelphia, Pa.; *Mechanical Equipment Subcommittee:* F. W. Egan, Frank W. Egan & Co., Bound Brook, N. J., chairman; *Literature Review Subcommittee:* C. G. Landes, American Cyanamid Co., Stamford, Conn., chairman; *Lamination Subcommittee:* J. E. Fenn, Consultant, New York, N. Y., chairman; *Waxed Paper Subcommittee:* L. M. Perry, Nashua Gummed & Coated Paper Co., Nashua, N. H., chairman; *Gummed Paper Subcommittee:* J. E. Sullivan, McLaurin-Jones Co., Brookfield, Mass., chairman; *Raw Stock Subcommittee:* R. T. Trelfa, Hercules Powder Co., Kalamazoo, Mich., chairman; *Pigments Subcommittee:* W. R. Willets, Titanium Pigment Corp., New York, N. Y., chairman; and *Testing Procedures Subcommittee:* Miss Lois V. Hans, St. Regis Paper Co., Deferiet, N. Y., chairman. *Plastics Committee:* E. C. Jahn, New York State College of Forestry, Syracuse, N. Y., chairman. The subcommittee chairmen were: *Fabrication and Structural Products Subcommittee:* E. C. Straka, Westinghouse Electric Corp., Micarta Div., Trafford, Pa., chairman; *Plastics in Paper Converting Subcommittee:* R. T. Nazarro, Texon, Inc., South Hadley Falls, Mass., chairman; *Resin Analysis Subcommittee:* W. A. Schenk, Riegel Paper Corp., Milford, N. J., chairman; *Cellulosic Materials Subcommittee:* F. A. Simmonds, Forest Products Laboratory, Madison, Wis., chairman; and *Resin Advisory Subcommittee:* Herman Mark, Polytechnic Institute of Brooklyn, Brooklyn, N. Y., chairman.

Research Development Division: H. W. Bialkowsky, Weyerhaeuser Timber Co., Longview, Wash., general chairman. *Bibliography Committee:* C. J. West, Institute of Paper Chemistry, Appleton, Wis., chairman. *Fundamental Research Committee:* H. F. Lewis, Institute of Paper Chemistry, chairman. (The Fundamental Research Committee sponsored a conference in Quebec, P. Q., during the year.) *Statistics Committee:* T. A. Pascoe, Nekoosa Edwards Paper Co., Port Edwards, Wis., chairman. *Microbiological Committee:* R. F. De Long, Marathon Corp., Rothschild, Wis., chairman. The chairman of the *Testing of Mildew Resistance Subcommittee* is B. F. Shema, Institute of Paper Chemistry. *Patents Committee:* Frank Makara, Patent Attorney, New York, N. Y., chairman.

Pulp Manufacture Division: Fred C. Goodwill, St. Regis Paper Co., Kalamazoo, Mich., general chairman. *Acid Pulping Committee:* J. M. McEwen, Weyerhaeuser Timber Co., Everett, Wash., succeeded George H. McGregor, Minnesota & Ontario Paper Co., as chairman. *Mechanical Pulping Committee:* F. W. O'Neil, New York State College of Forestry, Syracuse, N. Y., succeeded R. M. Drummond, International Paper Co., as chairman. *Alkaline Pulping Committee:* Henry Vranian, Chesapeake Corp. of Va., West Point, Va., chairman. (The Alkaline Pulping Committee sponsored a conference at Jacksonville, Fla.) *Chemical Products Committee:* Arthur Pollak, Consultant, New York, N. Y., chairman. *Paper Deinking Committee* (inactive), and *Pulp Purification Committee:* W. D. Harrison, Riegel Paper Corp., Milford, N. J., chairman.

Paper Manufacture Division: A. L. Sherwood, Sutherland Paper Co., Kalamazoo, Mich., general chairman. *Preparation of Papermaking Materials Committee:* J. J. Thomas, S. D. Warren Co., chairman (F. S. Klein, Byron Weston Co., Dalton, Mass., will succeed Dr. Thomas during the annual meeting in 1951). The chairmen of the subcommittees were: *Stuff Preparation and Sheet Formation Subcommittee:* L. A. Moss, Whiting-Plover Paper Co., Stevens Point, Wis.; *Fillers Monograph Subcommittee:* R. J. Proctor, Fitchburg Paper Co., Fitchburg, Mass., chairman; *Significance of Sizing Tests Subcommittee:* R. G. Mispley, Crown Zellerbach Corp., Camas, Wash.; and *Starch in the Paper Mill Subcommittee:* J. G. Bullard, Corn Products Refining Co., New York, N. Y., chairman. *Papermaking (Cylinder) Committee:* J. J. Harrison, Michigan Carton Co., Battle Creek, Mich., chairman. *Papermaking (Fourdrinier) Committee:* N. R. Phillips, Champion Paper & Fibre Co., Canton, N. C., chairman.

Testing Division: James d'A. Clark, Research Development Engineer, Longview, Wash., general chairman. *Fibrous Materials Testing Committee:* E. R. Schafer, Forest Products Laboratory, Madison, Wis., chairman. *Nonfibrous Materials Testing Committee:* J. P. Casey, New York State College of Forestry, Syracuse, N. Y., chairman. The chairmen of the subcommittees were: *Analysis of Coal Subcommittee:* L. H. Silvernail, Dow Chemical Co., Midland, Mich., chairman; *Testing of Enzymes Subcommittee:* Alexander Frieden, Pabst Laboratories, Milwaukee, Wis., chairman; *Testing of Rosin Size Subcommittee:* D. D. Cameron, Hercules Powder Co., Wilmington, Del., chairman; *Testing of Clays Subcommittee:* C. G. Albert, Edgar Bros. Co., McIntyre, Ga., chairman; *Testing of Coating Starches Subcommittee:* C. C. Kesler, Penick & Ford Ltd., Inc., Cedar Rapids, Iowa, chairman; *Wax Testing Committee:* A. M. Heald, Marathon Corp., Menasha, Wis., chairman. (This committee is also the TAPPI-ASTM Joint Committee on Petroleum Wax.) *Pulp Testing Committee:* L. V. Forman, Scott Paper Co., Chester, Pa., chairman; *Optical Properties Committee:* A. H. Croup, Hammermill Paper Co., Erie, Pa., chairman; *Microscopy Committee:* C. E. Brandon, Aetna Paper Div., Howard Paper Mills, Dayton, Ohio, chairman; *Paper Testing Committee:* A. K. Warner, Skinner & Sherman, Inc., Boston, Mass., chairman. The chairman of

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the *Erasing Properties Subcommittee* is P. W. Codwise, Beaver Wood Fibre Co., Thorold, Ont.; *Container Testing Committee:* W. R. Balster, Don L. Quinn Co., Chicago, Ill., chairman; *Packaging Materials Testing Subcommittee:* L. E. Simerl, Marathon Corp., Menasha, Wis., chairman. The chairmen of the subcommittees were: *WVP Subcommittee:* Charles Southwick, Jr., Consultant, Hope, N. J., chairman; *WVP of Completed Packages Subcommittee:* R. deS. Couch, General Foods, Inc., Hoboken, N. J., chairman; *Insect Resistance of Packages, Paper and Paperboard Subcommittee:* H. S. Gardner, Fiberboard Products, Inc., Antioch, Calif., chairman; and *Flavor and Odor Transfer Subcommittee:* A. H. Landrock, Massachusetts Institute of Technology, Cambridge, Mass., chairman. *Chemical Methods Committee:* A. S. O'Brien, Eastman Kodak Co., Rochester, N. Y., succeeded Milton Fillius of the same company as chairman. The chairmen of the subcommittees were: *Disperse Viscosity Subcommittee:* A. F. Martin, Hercules Powder Co., Wilmington, Del. (who succeeded Peter Van Wyck of the same company); *Alpha, Beta and Gamma Cellulose Subcommittee:* A. S. O'Brien, chairman; *Wood Subcommittee:* E. F. Kurth, Oregon State College, Corvallis, Ore., chairman; *pH of Paper Extracts Subcommittee:* M. S. Kantrowitz, Government Printing Office, Washington, D. C., chairman; and *Reducible Sulphur in Paper and Pulp Subcommittee:* C. P. Donofrio, New York State College of Forestry, Syracuse, N. Y., chairman.

Special Committees: *Standards Committee:* R. C. Griffin, Consultant, Needham, Mass., chairman. *Research Appropriation Committee:* J. L. Parsons, Hollingsworth & Whitney Co., Waterville, Me., chairman; and *Joint Textbook Committee:* George E. Williamson, Strathmore Paper Co., West Springfield, Mass., chairman.

R. G. Macdonald, *Secretary*, TAPPI

New Committee Chairmen

The following changes recently have been made in committees of the Technical Association:

Ray W. Foster of the Champion Paper & Fibre Co., Canton, N. C., has succeeded A. S. Goodrich of the Hammermill Paper Co., Erie, Pa., as Chairman of the Electrical Engineering Committee in the Engineering Division.

Edward M. Jenkins, Johns-Manville Research Center, Manville, N. J., has succeeded John E. Campbell of the Flintkote Co., Meridian, Miss., as Chairman of the Structural Fibrous Materials Committee in the Industrial Division.

Jules J. Perot of the Flintkote Co., Whippany, N. J., has succeeded Edward M. Jenkins as Chairman of the Raw Materials Testing Subcommittee of the Structural Fibrous Materials Committee.

Frederic S. Klein, Mill Manager of the Byron Weston Co., Dalton, Mass., has succeeded Joseph J. Thomas of the S. D. Warren Co., Cumberland Mills, Me., as Chairman of the Preparation of Papermaking Materials Committee in the Paper Manufacture Division.

Log Transfer Problems

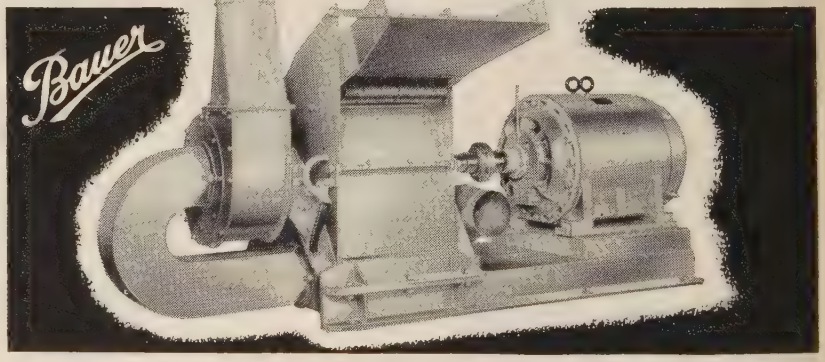
The TAPPI Materials Handling Committee is planning to consider the subject "Log Transfer Problems and Solutions," at the Sixth Engineering Conference to be held at Savannah, Ga., on Oct. 15–18, 1951.

Because of the scope of this problem which is common to most woodyards and its importance to all pulp and paper companies, the Committee requests the assistance of all members of the Technical Association. Pictures, sketches, and data pertaining to good practice, bad practice and their solution should be sent to the Acting Secretary of the Committee, W. R. McNally, 300 W. Pershing Road, Chicago 9, Ill., who will segregate and classify the material for the speaker whose name will be announced at a later date.

Impact mills for reducing chunky or bulky materials

It takes a well designed hammer mill to grind wood edgings, small blocks, pulp lap, agricultural residues, and other materials used in pulp and paper making. That's the kind of mill you see illustrated here—one of the Bauer No. 100 Series Hammer Mills.

Bauer Mills are heavily built for continuous service. All have the stamina to endure long punishment. And then the wearing parts can be readily renewed. The hammers and screens are alloy steel.

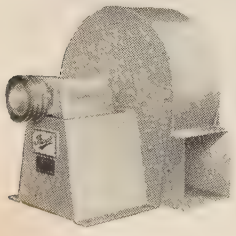


When an unusual situation arises, Bauer Mills are engineered for the job. Many special features have been developed for meeting a variety of requirements.

In the course of manufacturing and installing thousands of hammer and attrition mills, our company has developed a large line of related equipment, including Pulp Refiners, Permanent Magnetic Separators, Crushers, Feeders, and Exhausters.

You are invited to request our literature on any or all of these subjects. Your communications by mail, telegraph, or telephone will be given prompt and careful attention.

Bauer Exhausters



Bauer Exhausters are modern, clean lined, compact, substantial. They are frequently built-in accessories of hammer mills. Other applications cover all sorts of exhausting, ventilating, blowing, and dust collecting systems. When you have a project of this kind, submit all available data concerning the proposed installation so that we can give you specific information.

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Report of the Joint Textbook Committee

The Committee is happy to report that the first of the four volumes on the new series entitled "Pulp and Paper Manufacture" made its appearance last September. The McGraw-Hill Book Co., the publishers, are proud of this fully up-to-date work entitled "Preparation and Treatment of Wood Pulp." It is a beautiful and authoritative book without a rival or competitor in the world-wide field of pulp and papermaking. Many willing contributors, skillfully guided by the Editor, made possible this book of 1043 pages and more than 300 illustrations. It is estimated that authors and reviewers of manuscript devoted over 8000 hours to the project. The Committee deeply appreciates their invaluable help.

The same generous cooperation insures a correspondingly complete production of the other three volumes, progress on which is follows:

Volume 2—"The Preparation of Stock for Paper and Board" has been in the printer's hands for some months. The chapters are: (1) Treatment of Rags and Other Fibers; (2) Processing of Waste Papers for Boards and Printing Papers; (3) Beating and Refining; (4) Fillers and Loading; (5) Sizing of Paper; (6) Coloring of Paper.

Volume 3—"Manufacture and Testing of Paper" is complete except for parts of the chapter on Papermaking Machines. The tremendous job of making the many new illustrations for this volume has been proceeding for several months.

Volume 4—"Auxiliary Pulp and Paper Mill Equipment." The manuscript and drawings are well toward completion.

No prediction is possible as to the exact date when these volumes will be on the market, but every effort is being made to produce them as rapidly as circumstances permit.

The Committee would be remiss, did it not once more record its appreciation of the patient, untiring, and exceedingly capable editorship of J. N. Stephenson and the splendid cooperation of the McGraw-Hill Book Co. throughout the 32 years since the pulp and paper industry of North America initiated an educational project, the success of which has far exceeded the expectations of the little group which met in Buffalo, N. Y., in September, 1918.

ROYAL S. KELLOGG, *Secretary*

Research Appropriations Committee Report: 1950

During the past year six requests for research grants totaling $7900 have been received from TAPPI committees. These are listed as follows:

No. 24 (renewal). Project: Structure of lignin. Sponsored by Fundamental Research Committee. A sum of $1000 was granted for the continuation of the project.

No. 25. Project: Friction of stock in pipes. The sum of $500 was granted to the Hydraulics Committee for a mathematical analysis of the Brecht and Heller data on this subject.

No. 26. Project: Cellulose viscosity methods. The Research Appropriations Committee has unanimously approved granting the sum of $1200 to the Chemical Methods Committee. Recommended to the Executive Committee for action.

No. 27 (renewal). Project: Friction of stock in pipes. The Hydraulics Committee desires to continue its study of this subject and has requested a grant of $2200. This has been unanimously approved by the Research Appropriations Committee and has been referred to the Executive Committee for action.

No. 28. Project: Thermodynamic properties of ammonium and magnesium bisulphite solutions. The Acid Pulping Committee has requested an appropriation of $2000 for a study on this subject. This request is now being considered by the Research Appropriations Committee.

No. 29. Project: Construction and testing of two freeness testers of new design. The Raw Materials Subcommittee, operating under the Structural Fibrous Materials Committee, has requested financial assistance, amounting to $1000, for the construction of two freeness testers of new design preliminary to the carrying out of a testing program with these instruments. This request is now being reviewed by the Research Appropriations Committee.

Of the above requests, research grants (Nos. 24 and 25) totaling $1500 have been made by TAPPI. Nos. 26 and 27 have been approved by the Research Appropriations Committee and are now in the hands of the Executive Committee. Nos. 28 and 29 are currently being considered by the Research Appropriations Committee.

During the past year there has been a noticeable increase in interest on the part of several TAPPI committees to further their activities by the use of research grants. This should be expanded to other committee projects and it is suggested that the general chairmen of the TAPPI Divisions can be of considerable assistance in advising their respective committees concerning the availability of financial aid from the Association for their work.

The following projects of general interest to the pulp and paper industry, which TAPPI committees might include in their activities, have been brought to the attention of the writer.

1. The use of additives, including the newer latices, cellulose compounds, etc., to develop certain properties in paper.
2. A study of the properties of paper in relation to its use requirements.
3. A study of fiber properties in relation to their papermaking characteristics.
4. Color reversion and discoloration of bleached pulps.
5. Dispersing agents for fibers for better formation in paper.
6. Recovery of chemicals from neutral sulphite semichemical spent liquors.
7. Fire-retardant and flameproofing materials for paper.
8. Printing qualities of paper.
9. Penetration of liquids in paper.
10. Fundamental study of paper softness.

These problems, gathered from several sources, are offered as suggestions to Divisional Chairmen for their respective committees. The list could be expanded; it may stimulate the thinking of committee chairmen if brought to their attention, to the end that a greater use will be made of TAPPI research grants in the furthering of the objects of this Association.

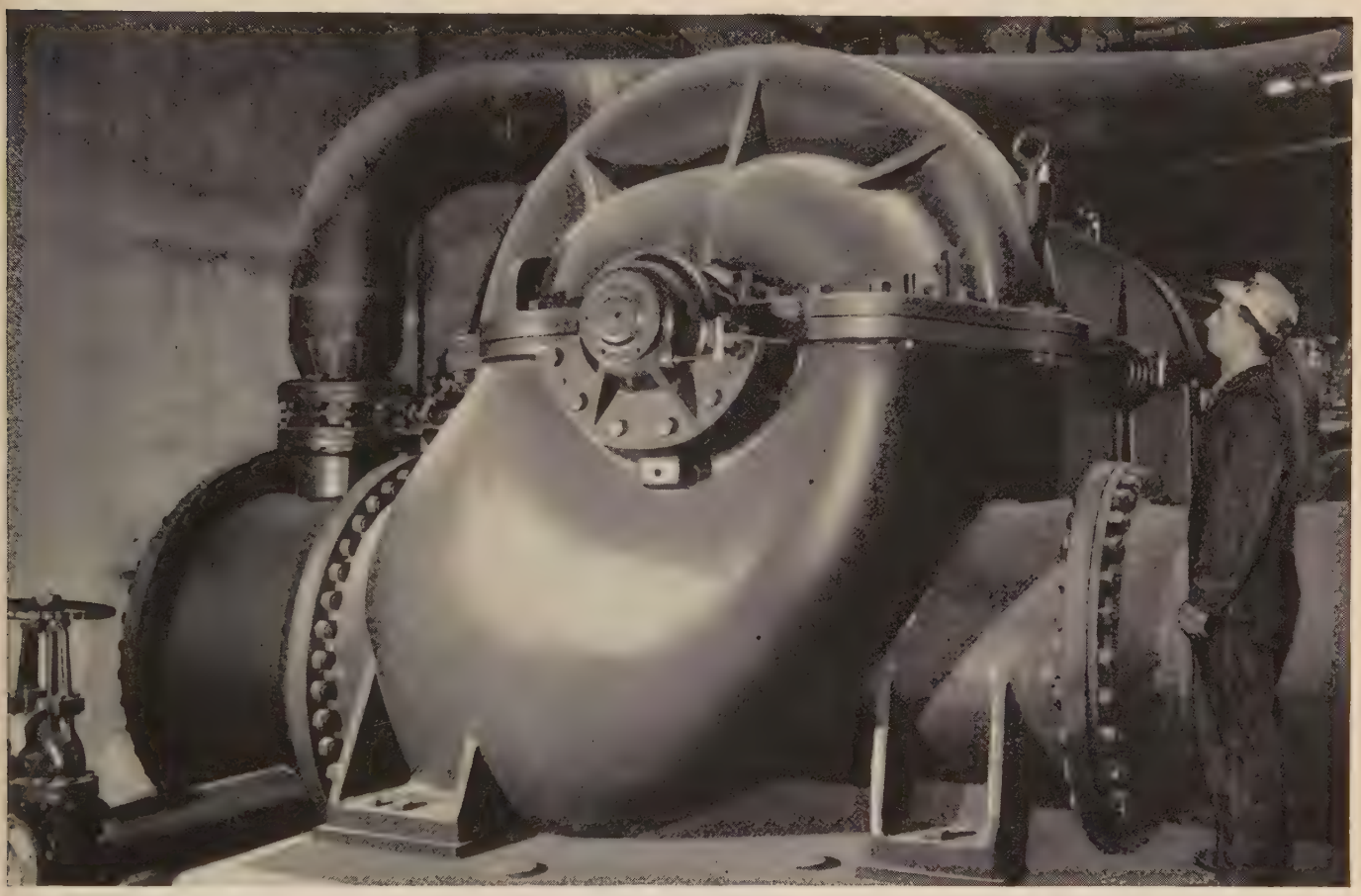
JOHN L. PARSONS, *Chairman*

Report of Standards Committee for 1950

So far as Standards are concerned, the committees of TAPPI, like the mills of the ancient gods, grind exceedingly slow; perhaps they are also attempting to grind too exceedingly fine. Several of the committee projects have been under way for five years or more. While, of course, a half-baked cake should not be offered for public consumption, it may be questioned whether it is worth while to deprive the public of a certain kind of cake for several years until the recipe has been developed to perfection and the most suitable frosting and trimmings have been selected. There are probably many methods which, while perhaps not suitable for TAPPI Standards, could and should be offered as Suggested Methods. The cake is of no use to anyone until it is removed

HERE'S WHY Southern Paperboard Corporation Called on Ingersoll-Rand for this huge

40,000 GPM PRIMARY FAN PUMP



Moving forty thousand gpm of water with all the stock for a 500 ton paper machine is a big job for any pump—a job that calls for maximum dependability, day after day, in continuous, heavy-duty service. This requirement, of itself, made Ingersoll-Rand the logical manufacturer to come to, because I-R pumps — in all sizes, types and capacities — have achieved outstanding records of dependable service in the pulp and paper industry.

This 36-inch, 30 foot total head, 400 HP primary fan pump is one of 43 I-R pumps installed at the Port Wentworth, Ga., plant of the Southern Paperboard Corp. And the company reports that maintenance records of *all* of these I-R pumps are exceptionally good.

This installation is typical of Ingersoll-Rand's ability to serve the pulp and paper industry—to supply standard or special pumps of *proven dependability,* for every paper-making application.

42 OTHER I-R PUMPS
serve this same paper mill

—handling liquids from fresh water to black liquor; in sizes, types and capacities ranging from small Motorpumps to the large unit illustrated.

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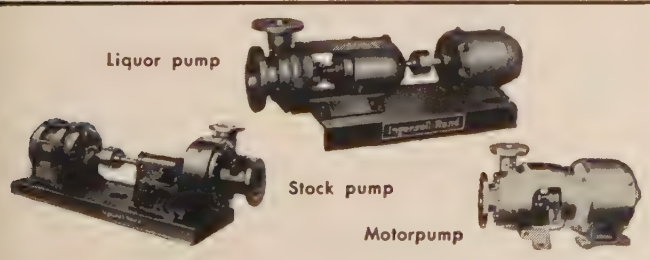

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from the oven. With war clouds on the horizon, it is hoped that the various committees will make every effort to complete their active projects as soon as possible so that TAPPI will not be caught with its Standards down.

Two new Tentative Standards were approved during the year and submitted to the Secretary for publication:

T 19 m-50. Pentosans in Wood (*1*)
T 1000 m-50. Thermal Conductivity of Structural Insulating Board (*2*)

A revision of Official Standard T 9 m-45, Holocellulose in Wood, was approved and published (*3*) and will later be submitted to letter ballot of the TAPPI membership for ratification.

A revision of Tentative Standard T 18 m-47, Specific Gravity (Density) and Moisture Content of Pulpwood, was approved and published (*4*).

Two Tentative Standards submitted to letter ballot of the TAPPI membership in the spring were advanced to Official Standards:

T 475 m-47. Bleeding Resistance of Asphalted Papers at Elevated Temperatures
T 633 m-47. Preparation of Magnesium Oxide Standard for Spectral Reflectance

It was decided to delay advancement of three others on the letter ballot, because of adverse criticisms.

Tentative Standard T 221 m-42 was approved, in corrected form, for advancement to Official Standard. It will be published and then submitted by letter ballot for ratification.

Two Suggested Methods were advanced to Tentative Standards:

T 800 sm-44. Drum Test for Fiberboard Shipping Containers
T 805 sm-45. Water Resistance of Shipping Containers (Shower Method)

At year's end four submissions were under consideration by the Standards Committee:

Forming Structural-Type Boards for Physical Tests of Pulp (new)
Specular Gloss of Paper at 70° (new)
Contrast Gloss of Paper at 57.5° (revision of T 424 m-45)
Specifications for Chrome-Nickel-Iron Alloy Castings for Sulphite Pulp Processing Equipment (revision of E 400 s-43)

The 19 items listed in last year's report (*5*) were issued in May. In August the manuscript for the 1950 printing of loose-leaf standards was sent to the New York Office and the corrected proofs were mailed to the printer in September, but at the end of the year printing had not been issued. The mailing will consist of:

2 new Tentative Standards
2 Suggested Methods advanced to Tentative Standards
2 Tentative Standards Advanced to Official Standards
1 revised Standard
15 corrected Standards

When the above are included the manual will comprise the following:

	Tentative	*Official*	*Total*
Standard Recommended Practices	2	11	13
Standard Specifications	4	1	5
Standard Testing Methods	44	112	156
Suggested Methods	..	..	14
	50	124	188

There was appended to our 1949 report a list of the assignments of each of the TAPPI Standards and Suggested Methods to the various committees. Since then certain changes have been made and these were published (*6*). To the list should be added the following:

Committee	
Chemical Methods	T 19 m
Structural Fibrous Materials	T 1000 m

It is intended to publish in the next Year Book certain additions to the Regulations Governing Standards which will cover the subject of committee jurisdictions. It might be well also to include in the Year Book the complete list of Standards under the jurisdiction of each committee. This would doubtless be useful to the various committee chairmen and members.

Harold C. Parish resigned as a member of this committee last February and A. Kenneth Warner, also of Skinner & Sherman, Inc., Boston, was appointed in his place.

In April TAPPI published in loose-leaf form a series of 157 Routine Control Methods. While these are in no way connected with our Standards or Suggested Methods, they deserve mention here both because of the tremendous cooperative effort involved in collecting, screening, and editing them and because some of them may ultimately prove suitable for developing into standard testing methods. These Routine Control Methods represent testing procedures in actual use in pulp and paper mills throughout the country. It is up to every individual TAPPI member as to whether the methods stop with No. 157 or continue to increase in number and value.

The development of a TAPPI Standard from its inception in the originating committee to its final publication for the loose-leaf manual is a long painstaking process. The committee members, and especially the chairmen, can shorten this process by answering letters promptly. If a complete answer cannot be given within a week or two, just scribble off an acknowledgment with an estimate of how long it will take to make a formal reply. The New York office can also help by giving priority to the publication of Standards in *Tappi* and by mailing the annual loose-leaf printing as promptly as possible. Our records show that during the years 1944–1948 it required 10 to 87 days to get a Standard published in the *Paper Trade Journal*, from the time copy was sent in until the printed Standard was received in the mail, the average time being 41 days. In the past two years, with the new journal *Tappi*, it has required from 49 to 137 days, the average being 95 days. With a monthly instead of a weekly journal, a priority on the printing of Standards would seem all the more necessary.

Undoubtedly one of the best stimulants to committee activity on standard testing methods has been the Testing Conferences. A summary of the last conference held at Rochester, N. Y., in September has been recently published (*7*). Anyone who reads this understandingly will feel like taking off his hat to Dr. J. d'A. Clark and the chairmen and committee members in the Testing Division. All those interested in testing methods should also read the thought-provoking article by A. E. Bachmann on "The Challenge to Testing" (*8*).

Literature Cited

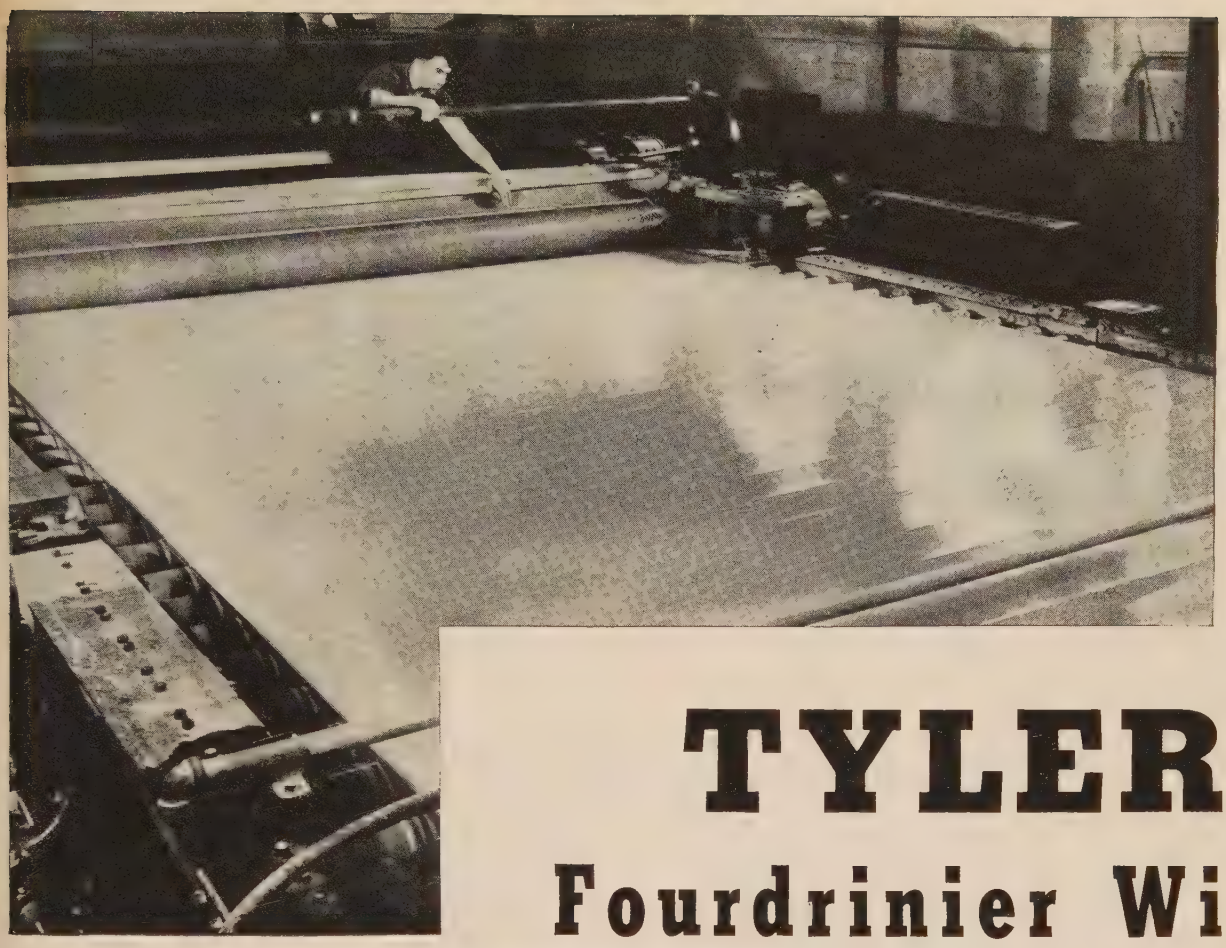
1. *Tappi* 33, No. 7: 89A (July, 1950).
2. *Tappi* 33, No. 7: 85A (July, 1950).
3. *Tappi* 33, No. 9: 100A (Sept., 1950).
4. *Tappi* 33, No. 3: 91A (March, 1950).
5. *Tappi* 33, No. 3: 88A (March, 1950).
6. *Tappi* 33, No. 8: 44A (Aug., 1950).
7. *Tappi* 33, No. 12: 74A–90A (Dec., 1950).
8. *Tappi* 33, No. 12: 24A–28A (Dec., 1950).

ROGER C. GRIFFIN, *Chairman*

Plastics in Paper Converting Subcommittee

The Plastics in Paper Converting Subcommittee of the TAPPI Plastics Committee met in the Board Room of the Technical Association, New York, N. Y., on January 10.

Those present were Ralph T. Nazzaro, Chairman, Texon, Inc., South Hadley Falls, Mass. (at the time Dr. Nazzaro was with the New York State College of Forestry, Syracuse, N. Y.); Maurice Beren, Pyrotex Leather Co., Leominster, Mass.; J. C. Pullman, American Cyanamid Co., Stamford,



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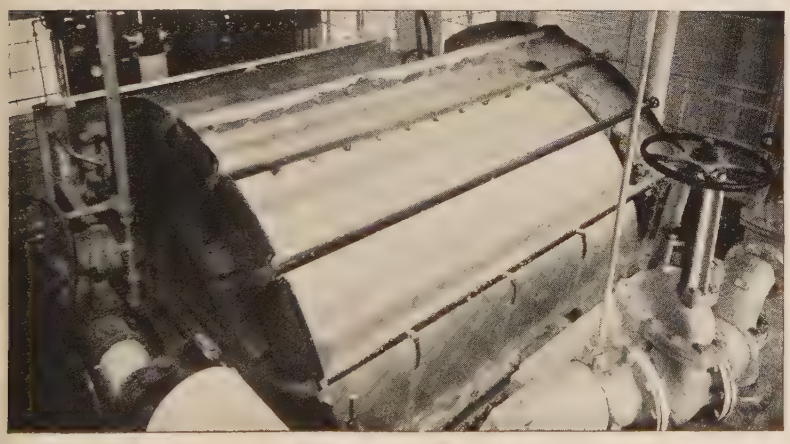
Fourdrinier Wires



Cylinder Wires

Filter Cloth

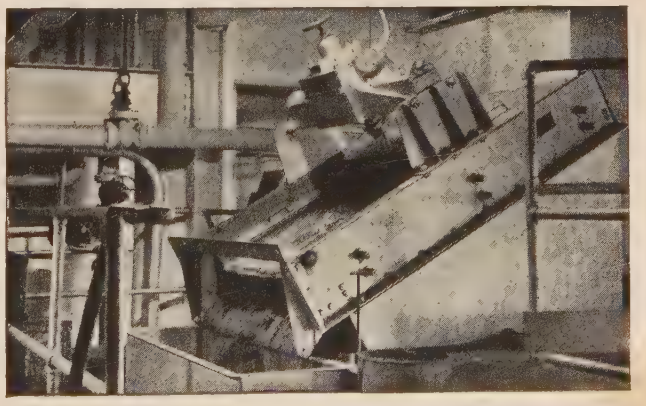
Washer Wires

Hum-mer Electric Screen →

For Wet Screening of Coatings, Colors and Fillers

Tyler-Niagara and Ty-Rock Chip Screens

Tyler Patch-Welder



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Conn.; G. E. Field, B. F. Goodrich Chemical Co., Cleveland, Ohio, and Paul Yoder, Pyroxylin Products, Inc., Paoli, Pa.

Two new items of business were discussed:

1. The question was raised whether the work of this subcommittee includes beater modifications of pulp where the high resin content does not permit a real segregation from converted paper made by saturation and/or coating processes. It was decided that the matter implies the need for more information on policies, and it was decided to leave the decision until after the general meeting of the Plastics Committee.

2. In view of the critical national situation and also since TAPPI is a nation-wide organization, it was felt by the members that this subcommittee should make a real contribution to the essential defense work of the many paper converters in our nation.

It was decided that a list of government specification numbers be prepared for publication in *Tappi* with an accompanying suggestive tabulation of the products which might be considered to meet the government's requirements.

The expanded activities of the subcommittee will require the assistance of other TAPPI members. Other members interested in this field will be invited to participate and volunteers will be welcome, in view of the possible contributions which the subcommittee can make during this national crisis.

The subcommittee accepted, after suitable alterations a list of definitions commonly associated with plastics in paper converting. Several tentative definitions were also considered. These follow:

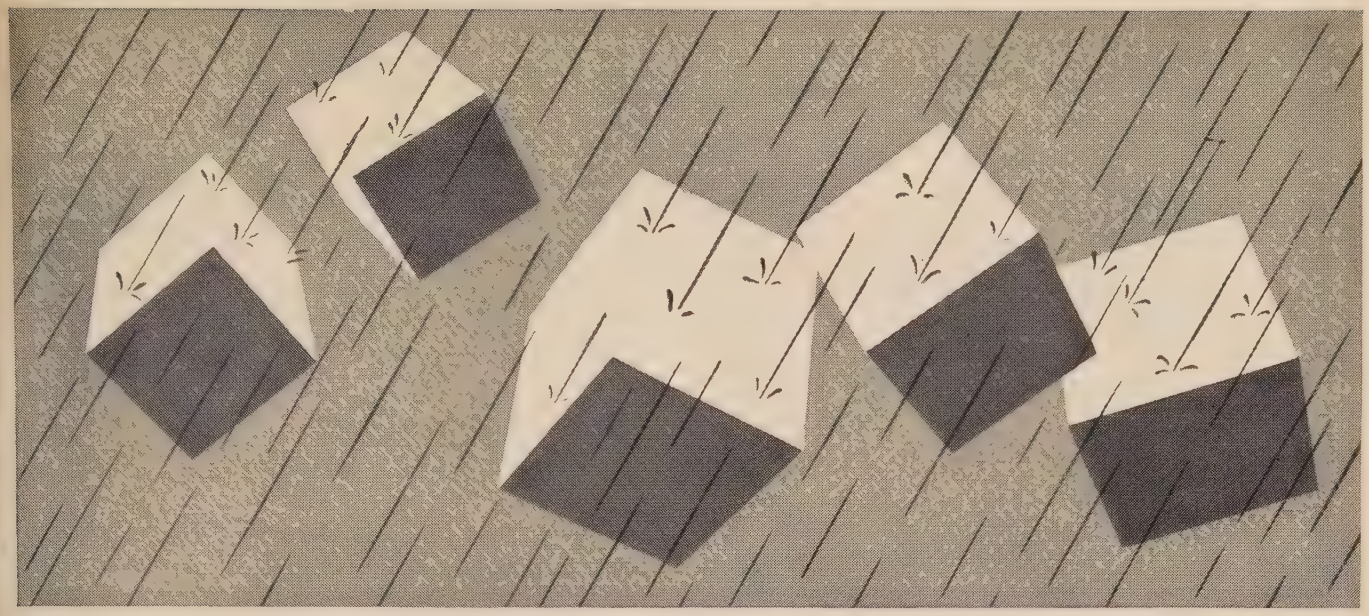
Definitions Fully Approved by the Committee

1. *Proofness*—The property of a material which results in infinite resistance to transmission or penetration of a medium. In general practice, however, the term proofness is used to designate a high degree of resistance under specified conditions. Since proofness is not achieved in practice, the term *Resistance* is recommended.
2. *Grease Resistance*—The property of a material to retard the passage of fats and oils. The specific fat or oil under consideration should be used as the test medium.
3. *Water Vapor Resistance*—The property of a material to retard the passage of water vapor. In practice the relative humidities, temperature and time conditons are specified.
4. *Water Resistance*—The property of a material to retard the passage of a liquid water.
5. *Flame Resistance*—The property of a material by which it does not support combustion (flame or afterglow) once the igniting source is removed. It is suggested that this term be used in place of fireproof.
6. *Abrasion Resistance*—The ability of a material to withstand marring, scuffing, or wearing away by an abrading surface.
7. *Blocking*—Blocking is the surface adhesion between sheets of like or unlike materials.
8. *Block Resistance*—The ability of a material to resist blocking under conditions of test or usage.
9. *Offsetting*—The transfer of all or part of a coating from the coated sheet to a contacting surface.
10. *Tack Point*—The point at which effective conditions, such as temperature or humidity, cause adherence of treated paper to itself or other surfaces without the application of pressure.
11. *Low Temperature Flexibility*—The ability of a material to remain flexible at low temperatures without loss of functional properties.
12. *Vermin Resistance*—The property of a material which causes it to resist the passage through, and destruction by vermin.
13. *Mold and Fungus Resistance*—The property of a material to inhibit the growth of or deterioration by microorganisms.
14. *Toxicity*—The property of a material to cause adverse physiological effects by contact or absorption.
15. *Heat Resistance*—The ability of a material to withstand elevated temperatures without decomposition or loss in functional properties.
16. *Cast Coating*—A two-step process of depositing a film upon an impermeable surface, and bonding it to a material while the film is still plastic.
17. *Spray Coating*—A process wherein a coating in atomized form is impinged upon a material.
18. *Roll Coating*—A process in which the coating is applied to the sheet by one or more rolls directly or through a transfer mechanism. The coating may be subsequently metered or smoothed by accessory equipment.
19. *Knife Coating*—A coating process in which a doctor blade, knife, or a straight-edged blade is employed to spread and control the amount of coating on a material.
20. *Immersion Coating*—A process of a coating on both sides of a material by dipping it into a coating bath.
21. *Calender Coating*—The roll application to material of coatings in a plastic state achieved by temperature and pressure only.
22. *Solvent Coatings*—Coatings deposited from organic solvent media.
23. *Water Dispersed Coatings*—Coatings which are deposited from an aqueous suspension, dispersion, or emulsion.
24. *Hot Melt Coatings*—Thermoplastic materials capable of application in the molten state without the aid of a vehicle. The coating is set fully on cooling to normal temperature.
25. *Organosol*—The suspension of finely divided solvated particles of a film-forming substance in a volatile nonsolvent organic medium.
26. *Plastisol*—The suspension of finely divided particles of a film-forming substance in a nonvolatile solvent which behaves also as a plasticizer.
27. *Saturation*—A process of introducing a fluid substance into and between the fibers of a fibrous material.
28. *Laminants*—Substances with adhesive properties at normal or elevated temperatures which are used for combining two sheets.
29. *Permanence*—That property of a material or substance which indicates infinite resistance to chemical or physical change under specified conditions. Since permanence is not achieved in practice, the term *Stability* is recommended.
30. *Stability*—That property of a material or substance which indicates resistance to chemical and physical change under specified conditions.
31. *Age Resistance*—A term which is synonymous with stability and has special reference to the element of time.
32. *Pressure Sealability*—The property of a surface by which, upon application of pressure, it will adhere either to other surfaces or to itself.
33. *Heat Sealability*—The property of a surface by which, upon application of heat, it will adhere either to other surfaces or to itself.
34. *Seal Strength*—The measure of the force which is required to separate two adhering surfaces.
35. *Delayed Action Sealability*—The property of a nontacky surface, which can be activated to a tacky state by the application of heat to enable bonding either to itself or to other surfaces during a limited period of time.
36. *Solvent Sealability*—The property of a surface by which, upon application of a solvent, it will adhere either to other surfaces or to itself.
37. *Acidity*—The percentage of total acid based on moisture-free material and obtained from an aqueous extract of the material under specified conditions.
38. *Alkalinity*—The percentage of total alkali based on moisture-free material and obtained from an aqueous extract of the material under specified conditions.
39. *Gloss*—A measure of the specular reflectance of light by a surface.
40. *Sweat Resistance*—The property of a material to resist the sorption of water from the atmosphere below the point where free water appears on its surface.
41. *Blooming*—The migration of an ingredient from the interior of a material to its surface.
42. *Crocking*—Blooming with specific reference to a coloring material.
43. *Blushing*—The precipitation of one or more ingredients in a coating, while it is in the fluid state, caused by the absorption of moisture from the air or by the formation of an unfavorable solvent balance.
44. *Barrier*—A material with special resistance to the passage of a particular substance.
45. *Lamination*—Combination of two or more plys of similar or dissimilar materials bonded by chemical or physical means into a single unit.

Tentative Definitions

1. *Extrusion Coating*—A process in which a plastic mass is forced through an orifice onto a surface.
2. *Chalking*—The formation of a powdery surface as a result of the disintegration of the film binder.
3. *Bleeding*—The migration of a coloring substance from one medium to another.
4. *Migration*—The movement of an ingredient within a medium or into another medium.
5. *Pigment Floating*—No definition agreed upon.

RALPH T. NAZZARO, *Chairman*



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PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

J. Marks Abernathy, Assistant Superintendent, American Cyanamid Co., Kalamazoo, Mich., a 1933 graduate of North Carolina State College.

Claude M. Adams, Assistant Manager, Southern Paperboard Corp., Port Wentworth, Ga., a 1937 graduate of the University of Florida.

Lyman C. Aldrich, Chemist, West Virginia Pulp & Paper Co., Covington, Va., a 1938 graduate of Oglethorpe University.

Andreas Andreassen, Superintendent, A/S Viul Tresliperi, Viul, Norway, a 1920 graduate of Horten Technical College.

Hanns F. Arledter, Hurlburt Paper Co., South Lee, Mass., a graduate of Technische Hochschule, Vienna, with a Ph.D. degree from Technische Hochschule, Darmstadt, in 1944.

Clayton L. Blondheim, Chief Chemist, St. Marys Kraft Corp., St. Marys, Ga., a 1936 graduate of the University of Alabama.

Richard F. Boll, Sales Manager, The Cleveland Container Co., Cleveland, Ohio.

George Burkhard, Control Superintendent, St. John Sulphite Ltd., Fairville, N. B., Canada, a 1942 graduate of the University of Berne, Switzerland, with a Ph.D. degree.

Charles C. Bush, Power Plant Superintendent, Union Bag & Paper Corp., Savannah, Ga., a 1930 graduate of Alabama Polytechnic Institute.

Joseph A. Cancelliere, Chemist, Premoid Products, Inc., W. Springfield, Mass., a 1944 graduate of Boston College, with an M.S. degree in 1948.

Irvin A. Clausen, Assistant District Manager, National Aluminate Corp., Chicago, Ill., a 1939 graduate of the University of Colorado.

Edwin W. Colt, Assistant Director of Research, Hair and Coated Abrasives Div., Armour & Co., Chicago, Ill., a 1924 graduate of Union College.

Frank Cooper, Librarian, Carbide and Carbon Chemicals Div., Union Carbide and Carbon Co., Charleston, W. Va., a 1946 graduate of Morris Harvey College.

Frederick G. Crane, Jr., Research Chemist, Crane & Co., Inc., Dalton, Mass., a 1944 graduate of Yale University.

Florimond A. Delforge, Chemical Engineer, Robert Gair Co., Inc., Uncasville, Conn., a 1935 graduate of Northeastern University.

William S. Eisner, General Manager, Sulphite Paper Mill, Newark Paraffine & Parchment Paper Co., Newark, N. J., a 1947 graduate of Lehigh University.

Henry B. Elkind, Jr., Supervisor, Central Quality Control Laboratory, The American Sugar Refining Co., Brooklyn, N. Y., a 1938 graduate of the University of Massachusetts.

Sanford A. Elliott, Assistant Pulp Superintendent, Brown Paper Mill Co., Inc., Monroe, La. Attended the University of Illinois.

John M. Ferguson, Superintendent, Soda Recovery Plant, Howard Smith Paper Mill Ltd., Cornwall, Ont., Canada, a 1940 graduate of the University of Toronto.

Robert E. Florine, Northwest District Manager, Swenson Evaporator Co., Seattle, Wash., a 1940 graduate of Washington State College.

John R. Fulghum, Process Products Engineer, Socony-Vacuum Oil Co., Chicago, Ill., a 1937 graduate of the University of North Carolina.

Aldo R. Gavazzi, Supervisor, Raw Material Quality Control, Ansco, Binghamton, N. Y., a 1938 graduate of State Teachers College, E. Stroudsburg, Pa.

Wilhelm Grunewald, Superintendent, Heinrich Nicolaus Paper Mfg. Co., Dachau, Munchen, Schliessfach, Germany, a 1922 graduate of Technische Hochschule, Dresden.

Carl A. H. Gyllenhoff, Technical Salesman and Consultant, Elof Hansson, Gothenburg, Sweden, a 1924 graduate of Darmstadt College.

Edward A. Haagensen, Manager, Pacific Coast Div., Bulkley, Dunton Pulp Co., Pasadena, Calif., a 1937 graduate of Montana State College.

Karl W. Heinlein, Resident Manager, Oregon Pulp & Paper Co., Salem, Ore.

Arnold D. Held, Assistant Chief Engineer, A.P.W. Products Co., Inc., Albany, N. Y., a 1949 graduate of the University of Michigan.

William T. Hill, Engineer, William T. Hill Engineering Service, Hoosick Falls, N. Y., a 1941 graduate of Rensselaer Polytechnic Institute.

Harold N. Holcombe, Technical Control, Schmidt & Ault Paper Co., York, Pa. Attended Ursinus College.

Theodor E. E. Hopner, Chief, Central Laboratory, Aschaffenburger Zellstoffwerke A.G., Aschaffenburg, Germany, a 1926 graduate of Technische Hochschule, Dresden, with Ph.D. degree.

Eugene N. Hruska, Analytical Research Chemist, Hoberg Paper & Fibre Co., Green Bay, Wis., a 1946 graduate of Fordham University.

Hideichi Ichikawa, Superintendent, Miyakojima Mill, Jujo Paper Mfg. Co. Ltd., Tokyo, Japan, a 1925 graduate of Tokyo University Engineering College.

P. M. Hoffman Jacobsen, Chief, Central Laboratory, A/S Nordisk Standard Saekke Selskab, Copenhagan, Denmark, a 1920 graduate of Royal Technical College.

Frank Kaulakis, Jr., Research Chemist, S. D. Warren Co., Cumberland Mills, Me., a 1936 graduate of Northeastern University.

Philip L. Knapp, Paper Salesman, Bulkley, Dunton & Co., Inc., New York, N. Y., a 1948 graduate of New York State College of Forestry.

John S. Knox, Engineer, Schmidt & Ault Paper Co., York, Pa.

Hirokata Kobayashi, Managing Director, Kokoku Rayon & Pulp Co. Ltd., Tokyo, Japan, a 1921 graduate of Tokyo Higher Engineering College.

Raymond A. Leask, Project Engineer, Abitibi Power & Paper Co. Ltd., Sault Ste. Marie, Ont., Canada, a 1941 graduate of the University of Alberta with an M.S. Degree in 1947.

Bert R. LeSaelleur, Cost Accountant, Brompton Pulp & Paper Co. Ltd., E. Angus, P.Q., Canada, a 1945 graduate of Sir George Williams College.

Bo A. O. Linderholm, Designer, Sandwell & Co., Inc., Seattle, Wash., a 1945 graduate of Technical College of Goteborg, Sweden.

Alvin A. Luce, District Engineer, The Torrington Co., Boston, Mass., a 1942 graduate of Worcester Polytechnic Institute.

John R. Lunt, Division Chemist, Robert Gair Co., Inc., Haverhill, Mass., a 1947 graduate of the University of New Hampshire.

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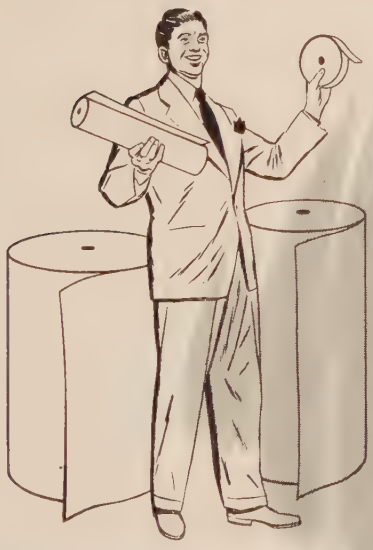

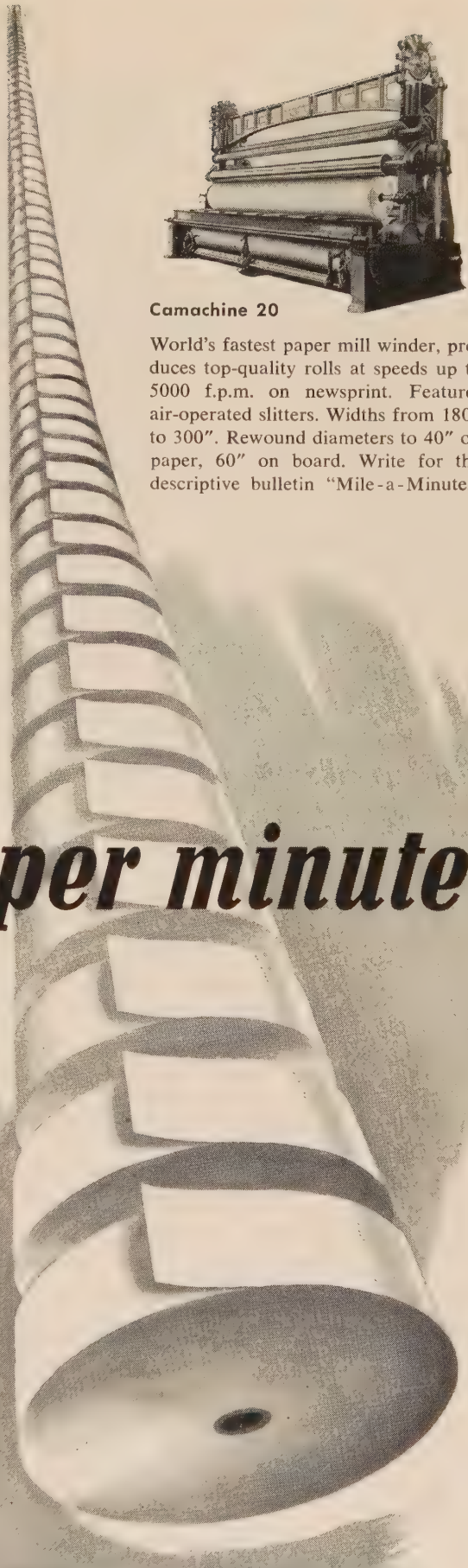

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Thomas E. Mackey, Supervisor of Analytical Research, E. I. du Pont de Nemours & Co., Rayon Technical Div., Richmond, Va., a 1940 graduate of Vanderbilt College.

Minoru Maki, Manager, Engineering Dept., Kushiro Mill, Jujo Paper Mfg. Co. Ltd., Tokyo, Japan, a 1928 graduate of College of Engineering, Machinery Dept., Tokyo.

Leland J. Manders, Research Chemist, Hoberg Paper Mills, Inc., Green Bay, Wis., a 1948 graduate of St. Norbert College.

William P. Manley, Viscose Supervisor, Hercules Powder Co., Hopewell, Va., a 1943 graduate of Iowa State College.

John M. McClure, Student, University of Maine, Orono, Me.

James D. McLean, Research Chemist, Abitibi Power & Paper Co. Ltd., Sault Ste. Marie, Ont., Canada, a 1941 graduate of McGill University with an M.S. degree.

Frederick J. McLeod, Assistant Technical Director, C. H. Dexter & Sons, Inc., Windsor Locks, Conn., a 1936 graduate of Brown University.

Charles J. Meloun, Application Engineer, Paper Industry, General Electric Co., Schenectady, N. Y., a 1942 graduate of Case Institute of Technology.

Frederick P. Moden, Control Superintendent, Anglo-Canadian Pulp & Paper Mills Ltd., Quebec, P. Q., Canada, a 1946 graduate of the University of Toronto.

Shigejiro Nakajima, Director and Superintendent, Yatsushiro Mill, Jujo Paper Mfg. Co. Ltd., Tokyo, Japan, a 1925 graduate of Tokyo College of Engineering.

George M. Norton, Superintendent, F. E. Norton & Sons, Inc., Henniker, N. H.

Norman H. Nuttall, Manager, Paper Mill Dept., Stein-Hall & Co., Inc., New York, N. Y., a 1938 graduate of The Citadel.

Jack C. Nutter, formerly of John Inglis Co., Ltd., is now Chief Engineer, Gair Co. of Canada Ltd., Toronto, Ont.

Aron Orrmell, Director, Kramfors Aktiebolag, Kramfors, Sweden, a 1914 graduate of Chalmers Technical High School, Gothenburg, Sweden.

Eugene R. Poston, Stock Tester, Pulp and Paper Div., Diamond Match Co., Plattsburg, N. Y., a 1950 graduate of College of the Holy Cross.

Thomas E. Price, Chemist, Parsons Paper Co., Holyoke, Mass.

William R. Price, Jr., Sales Service Engineer, Georgia Kaolin Co., Elizabeth, N. J., a 1950 graduate of Case Institute of Technology.

Carl Rosenblum, Chemist, Rose Ribbon & Carbon Mfg. Co., Inc., Harrison, N. J., a 1938 graduate of the College of the City of New York.

Takeshi Sato, Managing Editor, *Journal of Japanese TAPPI,* The Japanese Technical Association of the Pulp and Paper Industry, Tokyo, Japan, a 1917 graduate of Tokyo Imperial University.

Joseph Schonberg, Engineer, Hudson Pulp & Paper Corp., Southern Div., Palatka, Fla., a 1948 graduate of Pennsylvania State College.

Irwin S. Shindler, Technical Control, Schmidt & Ault Paper Co., York, Pa., a 1929 graduate of Gettysburg College.

G. Robert Sido, Chemist, Monsanto Chemical Co., Plastics Div., Springfield, Mass., a 1942 graduate of Westminster College, with an M.S. degree from Washington University in 1944.

Joseph C. Shipman, Librarian, Linda Hall Library, Kansas City, Mo.

Alvin R. Sinclair, Technical Service Representative, American Cyanamid Co., New York, N. Y., a 1948 graduate of Western Michigan College.

Albert F. Smith, Research Supervisor, E. I. du Pont de Nemours & Co., Experimental Station, Wilmington, Del., a 1936 graduate of the University of Illinois.

Edward R. Stasilowski, Manufacturing Chemist, The Stevens Paper Mills, Inc., Windsor, Conn., a 1939 graduate of Worcester Polytechnic Institute.

Erik Stephansen, Director, Norwegian Pulp and Paper Research Institute, Skoyen, Norway, a 1919 graduate of the Norwegian Institute of Technology.

Everett A. Strain, Quality Supervisor, U. S. Gypsum Co., Cranford, N. J., a 1939 graduate of Carnegie Institute of Technology.

Lucien Tack, Manager, Papeteries de Belgique S. A., Duffel, Belgium, a 1926 graduate of the University of Ghent.

Morizo Takahashi, Executive Director, Jujo Paper Mfg. Co. Ltd., Tokyo, Japan, a 1918 graduate of Kyoto University.

W. Gordon Thompson, Supervisor, Packaging Control Laboratory, The Andrew Jergens Co., Cincinnati, Ohio. Attended the University of Cincinnati.

Warren L. Thompson, Chief Chemist, Mid-Continent Petroleum Corp., Tulsa, Okla., a 1926 graduate of the University of Minnesota.

Giichi Utaka, Acting Manager, Research Institute, Jujo Paper Mfg. Co. Ltd., Tokyo, Japan, a 1936 graduate of Pharmaceutical Section, Medical College, Tokyo.

O. James Walker, Jr., Research Chemist, Northeastern Paper Products, Quebec, P. Q., Canada, a 1942 graduate of the University of Alberta, with a Ph.D. degree from McGill University in 1950.

Charles E. Weidmann, Manager, Technical Dept., Dyestuffs Div., Ciba Co. Ltd., Montreal, P. Q., Canada, a graduate of the Polytechnical School, Lausanne.

Ernest A. Wendt, Process Engineer, Marathon Corp., Menasha, Wis., a 1948 graduate of the University of Wisconsin.

Roland C. Whisler, Technical Control, Schmidt & Ault Paper Co., York, Pa., a 1938 graduate of Gettysburg College.

Philip G. Whiting, Jr., Technical Director, The Marvellum Co., Holyoke, Mass. Attended Lehigh University.

Kevin A. Wilkinson, Works Chemist, Backhouse & Coppock Ltd., Sutton Mills, Macclesfield, England, a 1950 graduate of Trinity College, Dublin.

A. Dale Wolvin, Quality Control Engineer, Empire Box Corp., South Bend, Ind., a 1946 graduate of the University of Nebraska.

Isawo Yamada, Director, Toyama Rayon Pulp Mill, Kokoku Rayon & Pulp Co. Ltd., Tokyo, Japan, a 1928 graduate of Tohoku Imperial University.

TAPPI Notes

J. Rex Adams is now Research Chemist for the Old Colony Envelope Co., Westfield, Mass.

James O. Starkweather, formerly of Hollingsworth & Whitney Co., is now Asst. Engineer for the Great Northern Paper Co., Millinocket, Me.

Le Roy J. Bauer, formerly of B. C. International Ltd., is now Sales Engineer for the Black-Clawson Co., Middletown, Ohio.

Robert A. Baum is now Manager of the Engineering Sales Division of Bulkley, Dunton Pulp Co., New York, N. Y.

Charles D. Beck is now Industrial Application Engineer for the General Electric Co. at Schenectady, N. Y.

Claes O. Berggren, formerly Paper Chemist for Personal Products Corp., is now with Co. C, 303 Signal Service Br., Camp Gordon, Ga.

Thomas F. Button of the St. Regis Paper Co. has been transferred from Los Angeles to New York City where he has charge of sales of certain papers and boards.

Charles E. Cashman, Jr., formerly of Crocker, Burbank & Co., is now in the U. S. Air Forces.

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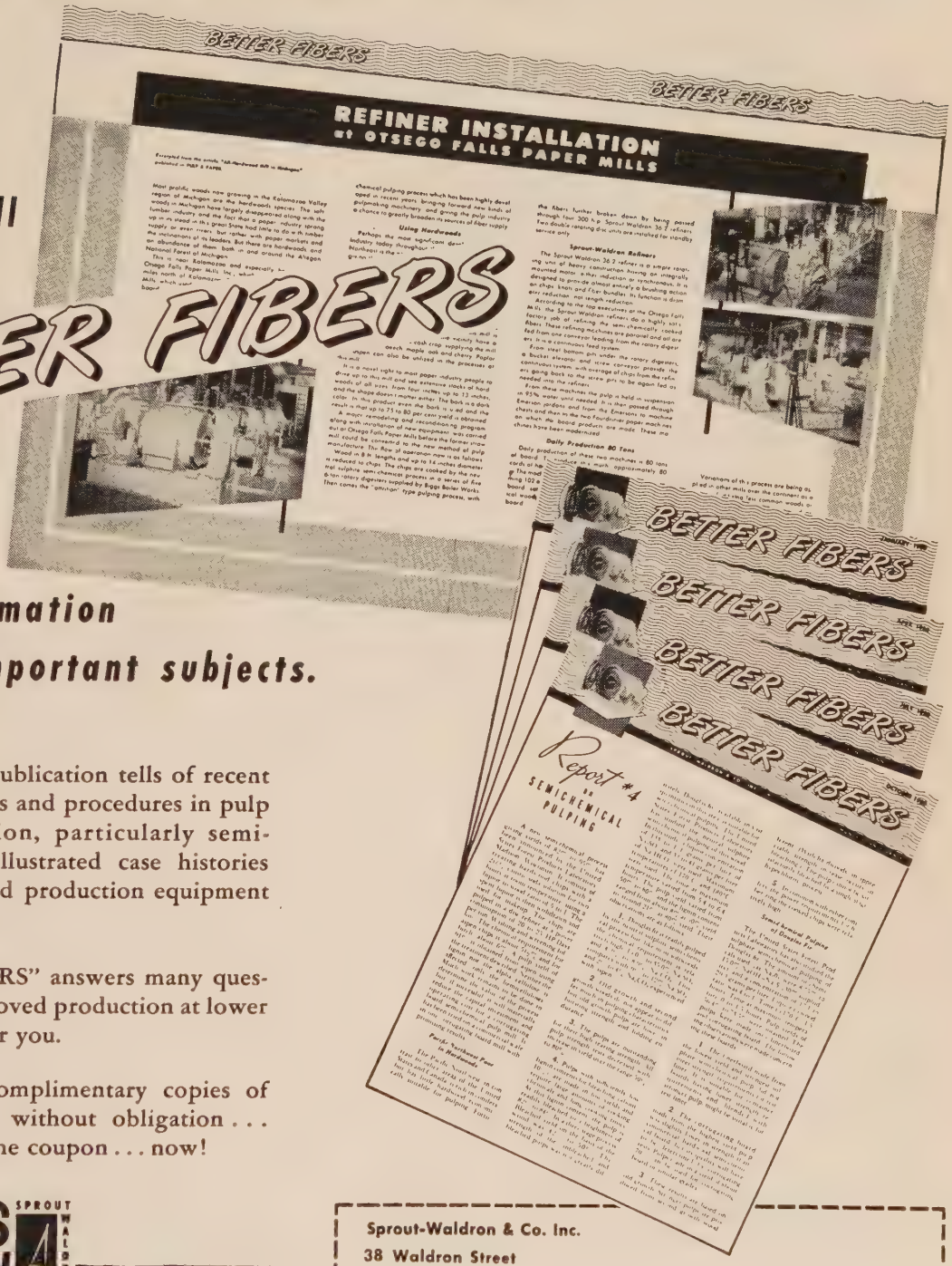

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Arthur L. De Spain, formerly of the Brown Co., is now Project Engineer for Chas. T. Main, Inc., Boston, Mass.

Robert M. Drummond is now Chief Chemist in the Research Division of the International Paper Co., Glens Falls, N. Y.

Philip Goldstein, formerly of the Lynn Wood Heal Co., is now Technical Director of Court Products, Inc., Haverhill, Mass.

Milton J. Gordon is now Asst. Mill Manager of the Columbian Mill of Peter J. Schwietzer Co., Smith Division, Lee, Mass.

John F. Hegeman is now Asst. Kraft Mill Superintendent of the Brown Co., Berlin, N. H.

Burton E. Helberg, formerly of the New York State College of Forestry, is now Chemical Engineer in the Chemical Division of the Lion Oil Co., Eldorado, Ark.

Herbert L. Hergert, formerly of the Institute of Paper Chemistry, is now at the Oregon State College and working part time for the Oregon Forest Products Laboratory, Corvallis, Ore.

James J. Higgins, formerly of the Institute of Paper Chemistry, is now Development Chemist for the Ohio Boxboard Co., Rittman, Ohio.

Frank E. Hill, formerly of the Union Bag & Paper Corp., is now with Texon, Inc., South Hadley Falls, Mass.

Arthur R. Ingham, formerly of Kupfer Bros. Co., is now with Wyomissing Glazed Paper Co., West Reading, Pa.

Carl A. Ireton is now Vice President in Charge of Engineering and Development, Specialty Papers Co., Dayton, Ohio.

F. A. Janson, formerly of the Marinette Paper Co., is now Consulting Engineer with Central States Engineering Co., Appleton, Wis.

Hans Jenssen, Librarian for the Food and Agricultural Organization of the UN has been transferred from Washington, D. C., to Viale Ternie di caracalla, Rome, Italy.

Werner Kaufmann is now President of the Kupfer Bros. Paper Co., Chicago, Ill.

Frank J. Lovegren is now Paper Supervisor for W. C. Hamilton & Sons, Miquon, Pa.

Mervin E. Martin is now Technical Supervisor of the Columbia Cellulose Co., Ltd., Prince Rupert, B. C.

Justin H. McCarthy, of the St. Regis Paper Co. has been transferred from Tacoma, Wash., to New York City as Paper Mill Engineer.

Robert W. Miller, formerly of the Simpson Logging Co., is now Process Control Supervisor for the Masonite Corp., Ukiah, Calif.

Ralph T. Nazzaro, formerly of the New York State College of Forestry, is now Director of Research for Texon, Inc., South Hadley Falls, Mass.

Philip E. Nethercut, formerly of the Watervliet Paper Co., is now Process Control Engineer for the Scott Paper Co., Chester, Pa.

Floyd W. Nienow, formerly Chief Engineer of the Ward Paper Co., is now with the Marathon Corp., Menasha, Wis.

George L. Nystrom, formerly of the Eastern Corp., is now a Lt. Commander, USNR, with the Inspector of Machinery, USN.

Charles E. Roth, formerly with the Mead Corp., is now Superintendent, Riegel Carolina Corp., Acme, N. C.

Caleb S. Taft, formerly of the International Paper Co., is now CIC Officer, U.S.S. *Collett* (DD 73d), c/o F.P.O., San Francisco, Calif.

M. J. Taylor, formerly of the Wisconsin Tissue Mills, is now with A. L. Adams Paper Co., Baldwinsville, Mass.

Richard T. Trelfa of The Hercules Powder Co. has been transferred from Kalamazoo, Mich., to Wilmington, Del., as a Technical Service Engineer.

Gabriel T. Turula is now Quality Control Supervisor and Chemist for the American Coating Mills, Elkhart, Ind.

John T. Ward is now Chief Chemist of the Riegel Paper Corp., Milford, N. J.

John Winchester, formerly of Price Bros. & Co., is now Groundwood Superintendent of the Donnacona Paper Co., Donnacona, P. Q.

Charles E. Young is now Technical Assistant to the Paper Mill Superintendent, Crown Zellerbach Corp., West Linn, Ore.

* * *

John C. Wood, Vice-President in Charge of Manufacture, is now the official corporate representative in TAPPI of the Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich., succeeding Ralph A. Hayward, deceased.

* * *

Harry Wilson has succeeded C. C. Smullen as official representative of the Borden Co., Chemical Division, New York, N. Y., in TAPPI.

* * *

A. W. Plier, Executive Vice-President and General Manager, has succeeded C. E. Stakey, retired, as the official TAPPI representative of the D. J. Murray Mfg. Co., Wausau, Wis.

* * *

Alfred G. Blake has succeeded Gilbert Mason as the official TAPPI representative of Edgar Brothers Co., Metuchen, N. J.

* * *

Testing Machines, Inc., has removed its offices to 123 W. 64th St., New York 27, N. Y. H. Z. Schniewind and W. F. Bachelder are officers of this Company.

* * *

D. Clark Everest, Chairman of the Board of the Marathon Corp., Rothschild, Wis., has been elected President of the American Forestry Association.

* * *

The following companies have become members of the Technical Association in 1951:

Atlanta Paper Co., Atlanta, Ga.
Dianda & Cia, Ltda., Sao Paulo, Brazil
Hawthorne Paper Co., Kalamazoo, Mich.
Kalamazoo, Ltd., Birmingham, England
Kansaki Paper Mfg. Co., Ltd., Tokyo, Japan
Kokoku Rayon & Pulp Co., Tokyo, Japan
Portuguesa de Celulosa, Ca., Lisbon, Portugal

* * *

The following companies have become sustaining members of the Technical Association in 1951.

Louis Allis Co., Milwaukee, Wis.
American Key Products, Inc., New York, N. Y.
Ebasco Services, Inc., New York, N. Y.
H. K. Ferguson Co., Cleveland, Ohio
Hauser-Stander Tank Co., Cincinnati, Ohio
John Inglis Co., Ltd., Toronto, Ont.
Morningstar, Nicol, Inc., New York, N. Y.
Tremont Lumber Co., Chicago, Ill.

* * *

Frank W. Egan, President of the Frank W. Egan Co., Bound Brook, N. J., manufacturer of paper converting machinery, recently returned with his wife from a business trip to Italy, Switzerland, France, Belgium, Germany, Norway, Sweden, and England where he called on his distributors and visited plants where Egan machines have been installed.

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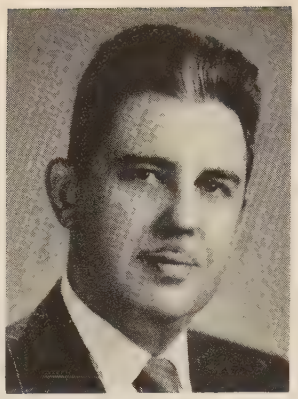
J. P. Rich



W. L. Rippeteau

John P. Rich was elected President of the Improved Paper Machinery Corp., Nashua, N. H., on January 19, 1951. Mr. Rich was born in Swanton, Vt., in 1906 and graduated as a mechanical engineer from the Massachusetts Institute of Technology in 1930. He worked for a year at the Groveton Paper Co., Groveton, N. H., and joined Impco in 1931, starting as a mechanic in the shop. The former President, Walter L. Barker, is now Chairman of the Board. The other Vice-Presidents are John H. Noble and E. R. Burling. Robert Nivison is Sales Manager.

* * *

Edward H. Petrick has been appointed General Sales Manager of the West Virginia Pulp and Paper Co., New York, N. Y. Mr. Petrick started with the company as a chemical engineer in the recovery plant at Covington, Va.

Industry Notes

The wire cloth manufacturers were notified by the National Production Authority that their estimated requirements for the first quarter were approved. Requirements for new looms that a few companies planned to install were not approved.

* * *

Walter L. Rippeteau has been appointed Manager, Chemical Sales Department, Michigan Alkali Division of the Wyandotte Chemicals Corp. He was formerly technical field representative of the research and development division and was instrumental in introducing sodium CMC to the chemical industries.

* * *

The Nekoosa-Edwards Paper Co., Port Edwards, Wis., will distribute a half million Norway and jack pine seedlings free to landowners in three adjacent counties. The two-year-old seedlings were raised from seed in the Nepco Lake Nurseries in central Wisconsin.

* * *

Seven price divisions are planned for the Economic Stabilization Agency to handle pricing of all commodities. These are: foods and restaurants; consumer durable goods; consumer soft goods; forest products, including paper products; industrial materials and manufactured goods; rubber, chemicals, and drugs; and transportation, fuel, services, imports, and exports.

* * *

The Research and Engineering Council of the Graphic Arts Institute has just released the second volume of the PIA Research and Operations Manual (June 1, 1950, to May 31, 1951). This covers new materials, new equipment, new methods, practices, and procedures. Subscriptions are available at $20 from the Research and Engineering Council, 719 Fifteenth St., Washington, D. C.

* * *

The mailing of income tax forms in Norway was delayed because of the paper shortage. The domestic market has been unable to compete with the Norwegian export market.

* * *

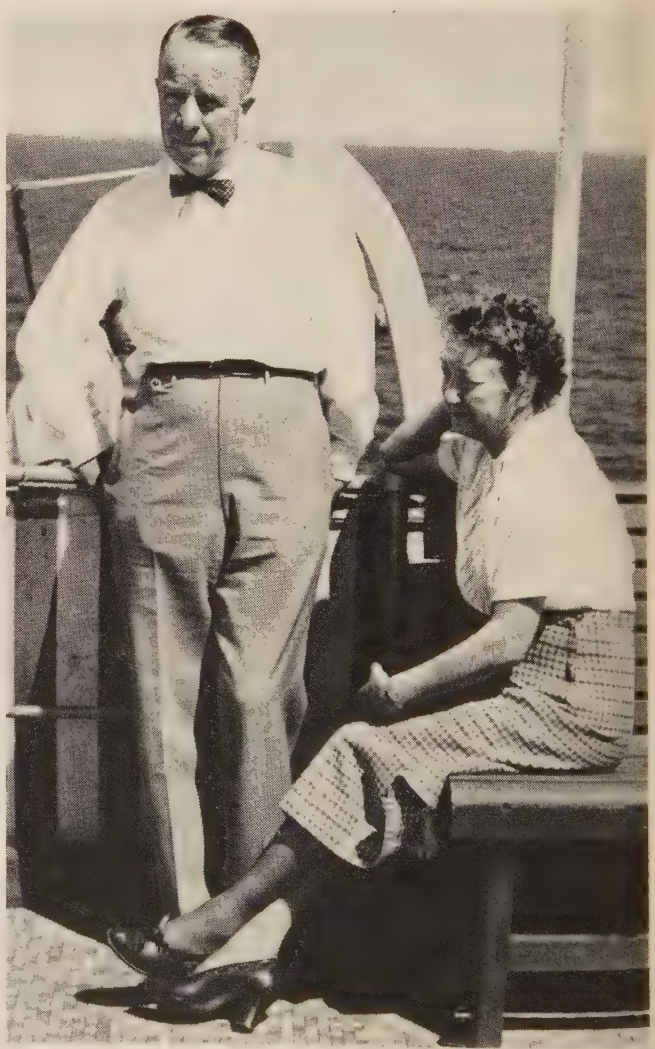
The N.P.A. has advised that expanded facilities for producing vinyl acetate monomer were made in February. Polyvinyl alcohol is used in the manufacture of V-board for military use.

* * *

The N.P.A. Reg. M-31, in addition to assuring supplies of chlorine for municipal water supplies and other public health uses, provides a set-aside of 10% marketable production for DO orders. Marketable production is defined in the order as that portion of chlorine which remains for sale in the hands of a producer after deducting the amount of chlorine which he consumes in his other operations and after deducting the chlorine which he sells and delivers by pipe line.

* * *

Press reports from Mexico City state that a 12 million dollar newsprint paper mill is planned for Chihuahua State, which will utilize lumber industry waste products as a raw



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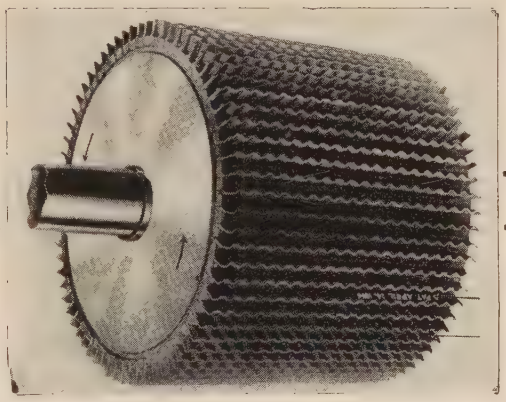

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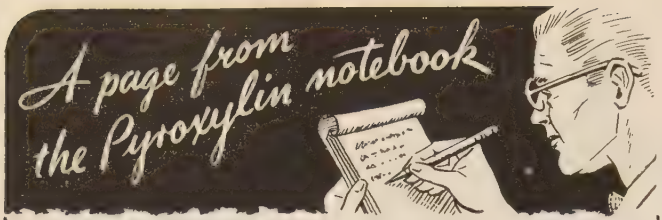

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#30-104-3—30% of GRI Butyl rubber in 155° MP microcrystalline wax. An additive for microcrystalline wax used for laminating glassine, paper, and foil. Increases viscosity, improves flexibility, and adds strength to the bond.

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material. Private investors and the government will supply equal amounts for financing the project.

* * *

The E.C.A. advises that requests to be placed on the mailing list to receive copies of all releases should be addressed to the Economic Stabilization Agency, 801 E. St., N. W., Washington 25, D. C.

* * *

A revised list of purchased items and purchasing locations of the Navy Department has been released. The booklet NAVEOX P-616 (Rev. 9-50), is available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., for twenty cents.

* * *

The Commodity Research Bureau, 82 Beaver St., New York 5, N. Y., has issued a 32-page handbook entitled "Your Social Security Benefits," designed for distribution by employers to their workers. Company officials or personnel executives of any organization which may be interested in distributing this booklet may send for a free sample copy.

* * *

G. A. Serlachius Oy., Manta, Finland, has ordered a new fourdrinier machine from J. M. Voith Co. in Germany. The machine, which is expected to be the largest greaseproof machine in the world, will trim 180 inches and produce 40 tons per day. The wire length is to be 32 meters. There will be 36 drying cylinders. The machine will commence production in December, 1951.

* * *

The first kiln in Finland for burning of lime sludge was erected by Oula Oy at its sulphate pulp mill at Nuottasaare in December, 1949. The rotating tube is 91.5 meters long and 2.4 meters in diameter. Its capacity is 90 tons of lime in 24 hours. The kiln was supplied by the Allis-Chalmers Mfg. Co. in the U.S.A.

The second kiln was erected in August, 1950, at Enso-Gutzeit Oy's mill in Kotka. The production is 50 tons of burned lime sludge per day. The kiln was obtained from Denmark. Its length is 62 meters and its diameter 2.5 meters. It is attended by two people. The Sunila Sulphate Pulp Mill is now building a kiln which will soon be ready for operation.

* * *

Crown Zellerbach Corp. is experimenting with alder logs for producing pulp. About two million feet of alder will be cut this winter and made into pulp at Camas, Wash. It is expected that the alder will make a short-fibered paper of little tear strength but with a smooth surface for printing and of considerable softness for tissue paper.

* * *

The British Industries Fair will be held at Earls-Court and Olympia, London, and Castle Bromwich, Birmingham, England, from April 30 to May 11, 1951. The fair, in its 36th year, will feature the products of 3000 manufacturers, representing 100 industries.

* * *

The Dusseldorf Fair (DRUPA) will be held at Dusseldorf, Germany, from May 26 to June 10, 1951. DRUPA will feature the paper and printing industries.

* * *

Slightly more than 8% of all of the paper produced in the United States is for the construction of paper bags and shipping sacks. In the first quarter of 1950 this amounted to 337,000 tons of paper.

* * *

The American Standards Association, 70 E. 45th St., New

York 17, N. Y., will send a copy of "How Big Is an Inch," by Senator Ralph E. Flanders of Vermont, to anyone on request. In this article Mr. Flanders tells why he is opposed to government control of standards activities.

* * *

The Chemical Construction Corp., New York, N. Y., has announced that it has a process in which it can recover elemental acid-grade sulphur from surface deposits. With deposits containing over 20% sulphur, the product can reportedly be marketed at current price levels. The process consists of grinding native sulphur-bearing ore, suspended in water, heating above the melting point of sulphur to coalesce the fine particles, cooking, and subjecting the final mix to froth flotation. Sulphur is floated off with the froth, and filtration yields the product ready for acid manufacture. A $1.5 million plant utilizing the process is now under construction in Columbia.—*Chemical Industries Week.*

* * *

The present price of a new chlorine plant is over $100,000 per ton-day of chlorine produced. In spite of the high cost, a number of small chlorine plants are now being built. Two paper companies in the United States and one in Canada and one chemical company are now installing chlorine plants to meet their needs.

* * *

The present rayon production capacity of 1.4 billion pounds annually will be increased 6% by July, and another 10% by October, 1952.

* * *

The Monsanto Chemical Co., Boston 49, Mass., has issued an interesting booklet on Better Sizing at Lower Cost with Mersize CD-2.

* * *

The Union Carbide and Carbon Corp., 989 Niagara Bldg., Niagara Falls, N. Y., has issued a bulletin on "Niaproof," a water-repellant finish for paper, wallpaper, wallboard, boxboard, and other paper products. Unsized boxboard and corrugated boxboard storage and shipping containers treated with Niaproof are said to resist dampness when stored on damp floors or exposed to rain or snow.

* * *

J. A. Flobeck has been appointed assistant manager of the New York-New England branch sales office of Diamond Alkali Co. He is located at 122 E. 42nd St., New York 17, N. Y.

* * *

Experiments with the ammonium base process of manufacturing sulphite pulp are scheduled to start at the Interlake Mill of the Consolidated Water Power & Paper Co., Appleton, Wis. The calcium base process has long been standard in the Wisconsin sulphite industry, but spent sulphite liquor, which is a waste material from the calcium base pulping process, tends to scale up evaporator surfaces and to produce fly ash when disposed of by evaporation and burning.

At its Wisconsin Rapids sulphite mill, Consolidated recently concluded a ten-day experimental run on ammonium base pulping. All six digesters were operated on ammonium base for the entire period.

The purpose of the Wisconsin Rapids test was to produce data on yields, qualities, and costs in comparison with the calcium base process. Figures from this run have not yet been completely analyzed, but apparently nothing spectacular resulted. Sole production advantage of ammonium over calcium base found thus far is a slightly greater yield of pulp per ton of wood chips, accompanied by a corresponding reduction in screenings. Preliminary estimates indicate that this ad-

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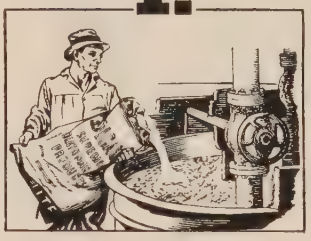

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Dicalite materials are more than fillers. A good number of mills use them for their proved effectiveness in aiding production as well. In board mills, for example, the chief advantage is improvement in sheet formation without increasing density and with faster drainage. Dicalite also increases liner coverage, often with improved brightness. In fine paper mills improved formation, saving in bleached sulphite pulp, and improved retention of titanium pigment are the salient benefits. Tissue and toweling mills find Dicalite affords pitch control, and at the same time secures uniform density.

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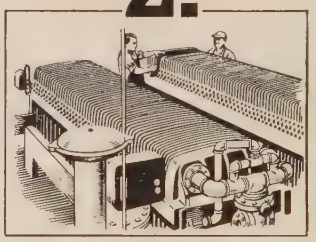

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A filtration system using Dicalite filter-aids, which will afford continued re-use of practically all machine water can be employed successfully on most board, pulp and paper machines. One large board mill, operating two of their four machines on a closed system, filters and re-uses all the machine water. They report savings in power and steam alone are sufficient to pay materials and operating costs, while realizing in addition the recovery of fine fibers as well as appreciable increase in felt life.

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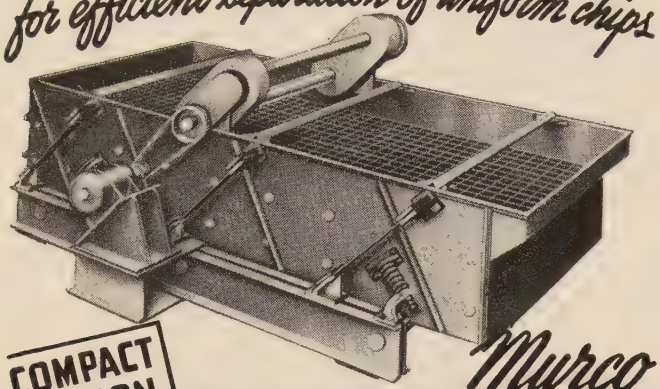

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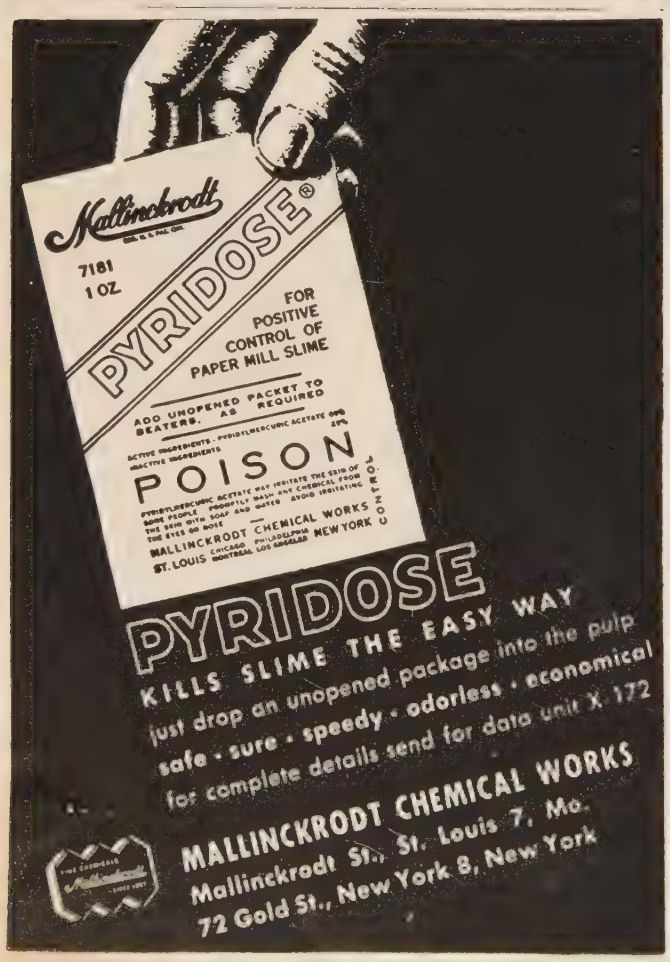
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vantage apparently falls short of meeting the additional cost resulting from use of ammonium in place of limestone in making up the cooking acid.

Executives and technical men at Consolidated consider that the possible advantages of ammonium base in simplifying the evaporation and burning of spent liquor are worth investigating, so they have decided to run one digester at their Interlake Mill for several days on the ammonium base process.

Besides giving production data on how effectively this process operates in this mill's equipment, the trial run will yield a sufficient quantity of ammonium base liquor for reasonably long burning tests. The evaporation pilot plant of the Sulphite Pulp Manufacturers' Research League adjoins the Interlake Mill at Appleton and is connected to this mill by a stainless steel pipe line.

Ammonium base liquor produced during this run will be piped into the League pilot plant for evaporating so that the concentrated material can be thoroughly tested as industrial fuel in Interlake's boilers. Consolidated is a member of the League, which is the organization through which Wisconsin sulphite mills conduct cooperative research to find ways for reducing stream pollution from spent sulphite liquor.

* * *

Research on evaporation of spent sulphite liquor will be expanded in the next few months by the Sulphite Pulp Manufacturers' Research League. An experimental evaporator has been ordered from a Pennsylvania manufacturer for delivery early this summer. The unit is of a type that has been successfully used in many chemical industries, but has never been extensively tested on sulphite liquor.

As one of the most promising ways to reduce stream pollution, Wisconsin sulphite mills have been trying to evaporate liquor and burn the residue as industrial fuel. Three companies' offers to test this method on full-scale operation are now in the hands of the State Committee on Water Pollution.

The only evaporator in Wisconsin capable of concentrating spent sulphite liquor so that it can be burned is in the League's pilot plant at Appleton. It was obtained 18 months ago. This unit has been operating to capacity ever since it was installed, concentrating spent liquor from various mills, to be used by these mills for burning tests. Quantity of concentrated liquor available for testing has set the pace for the combustion experiments.

As water is removed during evaporation, lime salts in the liquor tend to crystallize in deposits on the hot surfaces of the evaporator. The resultant scale interferes with operation of the equipment. To avoid this trouble, a Swedish-made evaporator has been used successfully which reverses the flow of liquor every few hours and thus washes the freshly deposited salts off the surface before it has time to harden.

The newly ordered evaporator operates on an entirely different principle that is expected to prevent formation of the crystals on the surfaces, rather than provide a way for removing them after formation. This permits a simpler design because no reverse flow is needed.

Like the Swedish unit already in use, the new unit is designed of stainless steel. The manufacturers claim low operating costs. This could be an important advantage, since the eventual adoption of any given method for reducing stream pollution must depend upon whether it can be used at a cost that is economically supportable.

* * *

University engineers will soon be studying how spent sulphite liquor improves road surfaces, and how to get the greatest benefit from this pulp and paper industry waste material when it is used for making Wisconsin's unpaved roads, streets, and highway shoulders harder and smoother. These are the principal purposes of a research contract entered into be-

tween the University of Wisconsin College of Engineering and the Sulphite Pulp Manufacturers' Research League.

Under its agreement with the University, the League will pay salary costs and other expenses of a University faculty member who will carry on the active investigation in the College of Engineering. Topics now scheduled for investigation are effects in compacting soil, increase in strength, loss of solids carried away by water, effect of quantities, frost resistance factors, and aging.

* * *

The Advisory Committee on Pulp and Paper Technology at the Western Michigan College nominated O. W. Callighan of Edgar Brothers Co., and F. C. Goodwill, Resident Manager of St. Regis Paper Co., as members of the Committee for a three-year term. The retiring members, W. A. Kirkpatrick, Allied Paper Mills, and Dwight L. Stocker of the Michigan Paper Co., will continue to cooperate with the Advisory Committee as chairmen of the Student Recruitment Committee and of the Plant Visitation Committee, respectively.

The meeting of the Advisory Committee was held under the chairmanship of E. E. Ludwig, Vice-President, Bermingham and Prosser Company. He paid tribute to the late Deyo B. Fox, Director of Vocational Education at the Western Michigan College. Dr. Fox's untimely passing brought to an end a splendid career. Dr. Wynand Wichers, Vice-President of the College, has taken Dr. Fox's place as *pro tempore* member of the committee.

* * *

The prewar pulp production capacity in Japan reached approximately 1,940,000 tons a year, but at the war's end it dropped to 1,072,000 tons or a 45 per cent decrease, as a consequence of the loss of Karafuto (Japanese Saghalien), Korea, and Formosa.

As regards the percentage of diminution in the different branches of production, sulphite pulp tops the list with a 67.3% decrease, followed in order by soda pulp 61.3%, kraft pulp 51.4%, rayon pulp 50.3%, and ground pulp with a 21.9% decrease stands bottom.

Owing to the great loss of pulp equipment capacity and the excessive deforestation carried out during the late war, postwar recovery of pulp production has been extremely slow as a whole. Individually, sulphite pulp production is much lower than that of the other kinds while ground pulp production is recovering fastest. The latter phenomenon is accounted for partly by the fact that ground pulp factories, whose equipment and machines are on minor industry levels, were widely distributed all over the country and suffered comparatively light war damage; and partly by the abnormal demand for paper during some years immediately following the end of the war when customers were satisfied with any paper offered, regardless of its quality, and many factories preferred production of ground pulp whose process is simple to that of sulphite pulp which requires more capital and technical skills than the other.

This marked loss of balance between sulphite pulp and ground pulp industries in point of their respective equipments, capacities, and outputs has created needs, from technical and material viewpoints, such as to force pulp and paper mills in postwar Japan to shift their gravity of production to low-grade articles.

Before the war more sulphite pulp had been produced than ground pulp. Reckoning the prewar output of ground pulp as 100, sulphite pulp claimed 109.5 in a prewar year, but after the war it dropped to the neighborhood of a ratio of 2 to 1, producing only 46.0 in 1947 and 56.7 in 1948. Such an unbalanced recovery of this particular industry has given an impetus to manufacture of low-grade paper through ample supply of material, but is hindering production of high-class paper. An analysis of operation of the various plants makes these phenomena more clear. The rate of operation of the

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ground pulp plants, in spite of their rapid recovery, is somewhere around 90% of the sulphite pulp factories whose productive revival index is low. This fact tells its own tale that the equipment capacity of sulphite pulp factories has already reached its maximum limits.

Thus, sulphite pulp, which cannot still meet demand fully, has its productive capacity fully operated but has reached its limit in strong contrast with the fact that ground pulp, which is being manufactured enormously, has yet much in reserve in the equipment phase. Such unbalance between ground and sulphite pulps forms the weak points of Japan's paper pulp industry on the material side as well as on the equipment side.

Increased supply of ground pulp has not only eased the demand and supply relation of pulp of all kinds, but also has caused demand for paper to move from lower-class goods up to high-class ones with the result that elimination of low-class paper makers is now being called for. The more high-class paper is demanded, the more is intensified shortage of sulphite pulp. This shortage of supply, moreover, is a phenomenon throughout the world and makes a big problem at present.

Now that the equipments of sulphite pulp plants are concurrent with those of rayon pulp plants, pulp makers may naturally choose to produce the latter. On the other hand, the pulp cost in chemical fiber industries as consumers of rayon pulp is much less than that of paper mills and they can afford to use more expensive pulp. This makes them interested in procuring rayon pulp and induces pulp makers to turn their attention to production of rayon pulp.

We may safely say that the present shortage of sulphite pulp is fundamentally due to the insufficient equipments. Pulp imported at length with sanguine expectation for the purpose of easing the domestic demand and supply relation, however, is exorbitant in price, so paper mills have to pool both domestic and foreign pulps in order to keep up the present standard of operation and at the same time to reduce the cost. These circumstances have put spurs to increasing demand for sulphite pulp when any prompt expansion of installations cannot be expected. In these days when pulp supplies are short all over the world, we think still some time will be required for solution of the problem.—*Fuji Bank Bulletin*

* * *

Robin S. Kersh has been named manager of the Westinghouse Electric Corp. Steam Division at South Philadelphia, Pa. This plant manufactures steam turbines, gears, steam condensers, blowers, and ship propulsion machinery.

Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa., has issued a 30-page booklet (B-4595) describing new DC Life-Line motors and generators.

The Westinghouse Engineer for January, 1951, is devoted to the Development Highlights of 1950.

W. G. Miller has been appointed Manager of Manufacture for the Westinghouse Motor and Control Division, Buffalo, N. Y.

* * *

R. W. Hooker, Vice-President of the Hooker Electrochemical Co., was re-elected President of the Chlorine Institute and First Vice-President of the Compressed Gas Association.

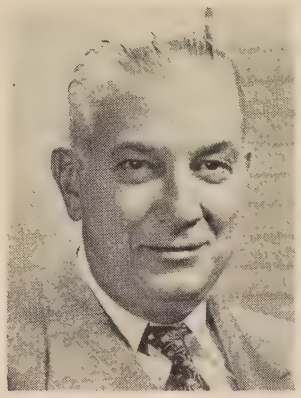
* * *

The new cellophane plant of Olin Industries, now being built at Pisgah Forest, N. C., is scheduled to be in full operation about September, 1951. The eight-machine plant will produce about 33 million pounds of cellophane a year.

* * *

Jack Watson has been appointed director of market research for the industrial products department of J. M. Huber Corp., New York, N. Y. He will investigate the applications and uses of new products and Huber clays in the paper, ce-

Jack Watson



R. C. Gangler

ramic, insecticide, and adhesive industries. Mr. Watson was manager of technical services of Huber's Ink Division.

* * *

The Newcomen Medal for achievement in the field of steam was awarded recently to Isaac Harter, Chairman of the Board of the Babcock & Wilcox Tube Co., Beaver Falls, Pa., at a joint meeting of the Newcomen Society and the Franklin Institute in honor of Benjamin Franklin's Birthday. Mr. Harter's achievement of note was in research to remove diffused oxygen from boiler feedwater and the application of this research to boilers into which were constructed economizers built with steel tubes. This development removed the cause of corrosion which had been preventing the use of steel economizer tubes.

* * *

The Atlas Mineral Products Co., Mertztown, Pa.. has issued a new Corrosion-Proof Linings Bulletin No. 4-1.

* * *

The Buffalo Electro-Chemical Co., Station B, Buffalo 7, N. Y., has released a 16-page data sheet on "Modification of Starches, Proteins and Gums with Peroxygen Compounds." Chemical modification of the high polymeric substances is needed to reduce their degree of polymerization, which is the main factor determining solution viscosity. The uses of peroxygen compounds to control depolymerization of most natural high polymers are explained.

* * *

Edwin S. Ladley has been named Assistant Director of Purchases of The Hercules Powder Co. He succeeds William L. Hewes, who retired in December, after 41 years of service.

* * *

The Black-Clawson Co. requests that all inquiries relative to Kohler unwinding and winding equipment be sent direct to the Dilts Division of B-C at Fulton, N. Y. John B. Kohler, consultant on the Kohler System, is located at Fulton.

* * *

Raymond C. Gangler was elected President of the American Cyanamid Co. on January 5. He succeeds William B. Bell who died on December 20. Mr. Gangler has been associated with the Cyanamid organization since 1917, when he joined the Company as a member of the accounting department.

* * *

The Industrial Chemicals Division of the American Cyanamid Co., 30 Rockefeller Plaza, New York 20, N. Y., has issued a technical bulletin No. 25 on Cyanamid's Automatic Emulsifier for Liquid Rosin Size. The emulsifier is a compact preassembled unit which is connected to tank car rosin-size storage facilities. The bulletin gives engineering data, details on how the unit operates, and flow diagrams.

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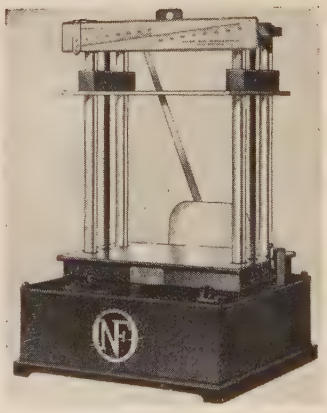

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Write for Brochures 491 and 492

A 250,000-square foot paper cup and container plant will be erected at Springfield, Mo., by the Lily-Tulip Cup Corp. This will be the ninth in the chain of the company's factories. It will employ 1500 people.

* * *

Oakite Products, Inc., 115A Thames St., New York 6, N. Y., has issued an interesting field service report on washing paper machine felts on or off the machine. Data are given on recommended solution concentrations, working temperatures, rinsing cycles, etc. It also describes the use of specialized acidic-type materials to remove hard-water calcium carbonate deposits lodged in felt fibers.

* * *

Edwin R. Bartlett has been elected Chairman of the Board of the Hooker Electrochemical Co., Niagara Falls, N. Y. R. Lindley Murray has been elected President.

* * *

Edgar H. Betts has been elected Chairman of the Board of W. & L. E. Gurley, Troy, N. Y. Charles A. Smart was re-elected President. R. G. Betts was elected Vice-President and Treasurer.

* * *

In 1950 the Johns-Manville Corp. established an all-time net-sales record of more than 200 million dollars. J. A. O'Brien, General Manager of the Industrial Products Division was named Vice-President. Harold R. Berlin, General Manager of Building Products, and A. S. Elsenblast, General Manager of the Celite Division, were also made Vice-Presidents. The new President is L. M. Cassidy who was Vice-President for Sales since 1946. Mr. Cassidy succeeds R. W. Lea, retired, who has joined Olin Industries.

* * *

E. de Vries Co., Division of the Paper Corp. of the United States, has been appointed exclusive sales agent for paper machinery in the British Isles and Continental Europe for Rice Barton Corp., Worcester, Mass. The E. de Vries Division is located at 630 Fifth Ave., New York, N. Y., and 480 Prinsengracht, Amsterdam, the Netherlands.

* * *

A series of time-saving, cost-cutting "firsts" highlighted the electrical industry's contributions to the paper and lumber industries in 1950, according to General Electric engineers.

The year 1950 marked the first industrial application of the G-E paper tensiometer. Also, the first complete amplidyne-controlled veneer lathe drive was installed during the past year.

An amplidyne-controlled log carriage drive was used for the first time outside regular sawmill operations in 1950. The year also saw the first steam turbine application for driving a log-chipper.

A substantial improvement in quality and an increase in production has resulted from the installation of three new "short roll" paper tensiometers for use on paper machines. These were installed on a board machine to indicate paper tensions. By supplying a signal to an existing speed-regulating system, the instruments provide overriding tension control. G-E engineers pointed out that a preset paper tension is maintained accurately regardless of variations in drying, machine loading, or stock condition.

In the first installation of its kind, amplidyne and electronic control was used to provide a completely coordinated drive on a veneer lathe, pressure roll, tipple, and trays for Puget Sound Plywood, Inc., Tacoma, Wash.

An amplidyne-controlled log carriage drive was installed in the breakdown plant of Masonite Corp.'s hardboard factory at Ukiak, Calif. Designed to handle 20-foot redwood logs with a full load carriage weight of 46,000 pounds, the new installation is the first of its kind outside sawmill operations.

A steam turbine was applied in 1950 to drive a log chipper in the new multi-million dollar paper mill of Fibreboard Products, Inc., at Antioch, Calif., marking the first time a turbine has been used in this way. A 2500-hp. G-E turbine powers the chipper so that logs 20 feet in length and 40 inches in diameter are reduced to chips at the rate of one foot per second. Three 5000-kva. turbine-generators develop the entire electrical energy for the plant. Exhaust from these turbines provides steam for the process of reducing the chips to usable cellulose fibers.

Using G-E sectional drives and winder drives, a new paper mill capable of producing approximately 300 tons of 32-pound newsprint daily was completed in 1950. The new plant, built for the Coosa River Newsprint Co., Coosa, Ala., utilizes two 226-inch newsprint paper machines which use multiple generator sectional drive with electronic-amplidyne regulators to operate at a top speed of 1800 feet per minute.

OBITUARIES

Robert J. Meagher

Robert J. Meagher, Director of Research for the Folding Paper Box Association of America, Chicago, Ill., died on January 21, 1951, of a heart attack after an extended illness.

Mr. Meagher was born in Chicago, Ill., on September 10, 1910, and graduated from the University of Southern California in 1931 with a bachelor's degree in chemistry. Since 1942 he was employed by the Folding Box Association of America. Mr. Meagher was a member of the Technical Association of the Pulp and Paper Industry.

Surviving are his widow, Mildred; two sons, Robert, Jr., and Thomas; a daughter, Helaine; his parents, Helen F. and Daniel Meagher; a sister, Mrs. D. M. LeHockey, and a brother, William D. Meagher. Funeral services were held in Chicago on January 24.

Frank F. Schrier

Frank F. Schrier, Development Engineer of the Downingtown Manufacturing Co., Downingtown, Pa., died suddenly at his home in Philadelphia, Pa., of a heart attack on January 23, 1951.

Mr. Schrier was born in Philadelphia in 1893 and completed his education at Drexel Institute of Technology, where he specialized in mechanical and structural engineering. He entered the employ of the Downingtown Manufacturing Co. in 1947.

H. van der Raay

The Cellulose Development Corp., Hatch Ebd, Middlesex, England, reports the death of its Chairman and Managing Director, F. G. L. Becker, and H. van der Raay, Chief Engineer of Celdecor Africa (Pty.) Ltd., in an air crash in British Cameroons on Saturday, February 3, 1951.

Mr. van der Raay was a member of the Technical Association of the Pulp and Paper Industry. He graduated as an electrical engineer from Middlebaar Technical College in 1925. From 1929 to 1931 he was an electrical engineer for the Bell Telephone Laboratories. From 1931 to 1938 he was engineer for the South African Gold Mines Ltd., and prior to going with Celdecor he was engineer for the South African Pulp and Paper Co. Ltd., until 1948.

LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel and Events

Ohio

The Ohio Section gathered 134 strong at the Manchester Hotel, Middletown, Ohio, on January 9, to hear two papers presented on the use of rubber latices and resins in paper and hardboard manufacture.

The program was arranged by R. A. Buck of the Sorg Paper Co. The speakers included William Aiken, Assistant Manager, Chemical Division, The Goodyear Tire & Rubber Co., Akron, Ohio, and Francis H. Snyder, President of The Snyder Chemical Co., Bethel, Conn.

Dr. Aiken spoke on "Beater Impregnation of Rubber Latices." Dr. Aiken discussed the variables affecting the resulting lattice-containing sheets under the following headings:

(a) Classes of rubbers used.
(b) Methods of compounding the rubber.
(c) Chemical composition.
(d) Molecular weight of the rubber.
(e) Percentages applied to the sheet.
(f) Effect of types of pulp on results.

Mr. Snyder spoke about "Some New Developments in the Beater Addition Process."

His paper discussed the use of special types of phenolic resins in the manufacture of a variety of specialty papers. Mr. Snyder stressed the results attained by adding the resin to the fiber at the head box. This is called the "Inverted" procedure as contrasted with the "Direct" in which the somewhat diluted phenolic resin is added to neutral stock in a beater followed by the addition of cation-yielding substances such as aluminum salts, acids, etc. Mr. Snyder illustrated his talk with numerous samples of products made from plastic impregnated fiber. Mr. Snyder's talk follows.

Some New Developments in the Beater Addition Process, by Francis H. Snyder

This paper is the third in a series which members of my staff and I are presenting with the object of acquainting the paper industry with our company's developments in the field of beater addition phenolic resins. The first paper* was presented at Portland, Me., on October 21, 1949, and the second† was presented at the National Meeting of TAPPI on February 21, 1950.

Our first paper was presented as a progress report and described a considerable list of plastics and specialty papers. The common denominator was that all were produced by the addition of special types of phenolic resins to wet pulp somewhere ahead of the forming wire in the papermaking process.

Recently we have begun to use what we call the "Inverted" procedure for the addition of these resins to pulp. Several types of products can be made in this manner which could not be produced by the "Direct" addition, as previously described. The "Direct" process involves the addition of the somewhat diluted phenolic resin to neutral stock in a beater or other suitable mixing apparatus followed by the addition of cation-yielding substances such as aluminum salts, organic or inorganic acids, etc. By this method the resin becomes attached as a thin glassy film to the individual fibers, and if standard precautions with respect to temperature, pH, and mechanical treatment are observed the stock may be converted into paper on standard paper machines in a perfectly uncomplicated manner. The process is, in fact, identical in practice with beater sizing with rosin.

The "Inverted" procedure is substantially one of headbox addition. The stock is acidified at some convenient point such as the mixing station, jordan inlet, or in the beaters. A sufficient amount of acid and/or alum is added to the stock to neutralize the resin which is to be added later and to leave a residual concentration of free acid equivalent to a pH of 4.5–5.0. It has been found that the outlet of the consistency regulator is a good point for the addition of the resin since all of the stock leaving the regulator goes to the machine and will not be recycled. The resin is usually made up in a tank having a capacity of a few hundred to a few thousand gallons and diluted with water to some preselected solids content which is usually of the order of 15 to 25%. A convenient and inexpensive device for controlling the flow of resin to the stock system is a rotameter or other flow-indicating device located in the line which delivers resin to the system. The resin is pumped with an inexpensive bronze or steel gear pump equipped with a variable speed drive. A convenient way of doing this is to use a pair of variable diameter sheaves or to run the drive motor from a continuously variable transformer. It has been found in practice that such a gear pump can be accurately calibrated and a curve constructed on coordinate paper showing gallons or pounds per minute vs. pump shaft r.p.m.

It is usually necessary to provide antifoaming agents when using these resins by either the "Direct" or "Inverted" processes. Many of the commercial defoamers work very well. We have recommended Defoamer No. 6, Hercules Powder Co., in many cases since this material gives excellent performance at moderate cost over the entire pH range encountered in this process. The defoamer should be used with care and according to the manufacturer's directions, and should be added to the stock before the resins go in. Aside from convenience, the "Inverted" procedure is indicated in all cases where brash and poorly refined fibers are used in the furnish. The "Inverted" procedure also applies where such relatively nonpolar fibers as wool, nylon and glass are employed.

The "Inverted" procedure is also used in the manufacture of wet process hardboards from Asplund fiber and from screenings. It has been found that $2^1/_2\%$ of resin added in this manner is as effective as about 6% added by the "Direct" process. Coprecipitation of SYNCO 721 and bituminous emulsions, using about $2^1/_2\%$ of each gives boards exceeding the Federal Specifications.

Another factor of importance is that in many paper or board making operations there are no facilities available for batchwise addition of resin, and, therefore, it is a case of the "Inverted" procedure or nothing.

Although the subject of phenolic wet strength *per se* is to be taken up in a subsequent paper, it might not be amiss to say here that most of the production of the new super-wet-strength papers is accomplished by the "Inverted" procedure even when concentrations of resin on the basis of the total furnish are as high as 35%. Wet strengths as high as 300% of the untreated dry strength have been obtained by these methods.

Molding Compounds

Brief mention has been made in previous papers of the pro-

* Snyder, F. H., "Manufacture of Plastics by the Beater Addition Process."

† Snyder, F. H., Spiwak, L., and Moyer, Alfred E., "The Beater Addition Process for Producing Laminating Papers."

duction of both general-purpose and light-colored molding compounds by the beater addition of phenolic resins to wet pulp. During the past year this process has been developed to a high state of utility, and some of the salient facts about the process of making such molding compounds and the use and properties of these materials will be discussed.

Generally, the production of thermosetting molding materials of the cellulose or wood-filled varieties involves the mechanical dispersion of a liquid or solid thermosetting resin into the filler by means of compounding rolls, heavy duty mixers, extruding machines, or combinations of these. This mixing is continued until the fibers are thoroughly covered with resin, and until the heat added or generated in the process has advanced the polymerization of the resin to the point where the desired molding characteristics are obtained. This process requires heavy equipment and a large expenditure of power. We have developed a wet addition process for the manufacture of molding compounds which consumes 10–25% as much power as the conventional processes with a corresponding reduction in plant and production cost.

It has been possible by this process to produce many modifications which were difficult or impossible to make by the older methods. For example, we have been able to reach impact values of from 1.2 to 1.4 with a bleached sulphite pulp filler. It is generally conceded that an impact strength of 0.5 is about all you can expect from sulphite pulp. About the same values are ordinarily obtained from kraft pulps. The older materials are also quite bulky and are usually dusty.

The following example is given to illustrate the new process: A light ivory-colored thermosetting molding compound of medium flow having outstanding resistance to staining and to breakage was desired. An impact of 1.0 was specified. To obtain this impact it had been necessary to employ a bleached cotton rag filler and a melamine-phenolic binder which gave a deeply mottled brown product which stains very badly in service. We produced a compound as follows:

One thousand pounds of bleached northern kraft is beaten to a Canadian Standard freeness of 500–550. The temperature in the beater is adjusted to approximately 95°F. and the following are added:

Water dispersed titanium dioxide	5 pounds
SYNCO 421 (100% solids basis)	1000 pounds
Diluted with water	2000 pounds
Chrome yellow	100 grams

The resin was precipitated by the addition of precipitant "K" which contains 150 grams of acetic acid and 20 grams of phosphoric acid per liter. The pH in the beater is brought down to approximately 4.5. It should be noted that alum is not used when a great deal of flow is desired in either molding or laminating materials.

The resin-pulp complex is thickened on a wet machine, or it may be run on any type of paper machine, and partially dried to a total volatile content of approximately 25%.

Actually very little drying is required to reach this volatile content since one half of the weight of the product is resin which is dry anyway. As a matter of fact, if wet laps are piled up between felts and subjected to hydraulic pressure of a few hundred p.s.i., the moisture content will come down into the required range. A screw press achieves the same result and this equipment is recommended for large-scale production.

When these boards or papers are finally densified and dried the molding compound is finished. Various methods are available for the finishing step. One of these is to run the moist board on heated compounding rolls at low power, driving the moisture off and taking the material from the rolls at a volatile content of approximately 8%. The product is put through a hammer mill or chipper to reduce it to size.

The most convenient method, however, is to pass the moist board through an extruder using approximately $^1/_8$-inch die plates. A dense, coherent, spaghettilike filament is produced, and this is broken up into short pieces by means of a cutter, and the product dried in a current of warm air at a temperature of 110–140°F. to a volatile content of 6–8%. Drying conditions are selected to produce the desired degree of flow during molding.

This molding compound may be compression or transfer molded at pressures from 1000 to 5000 p.s.i., at temperatures around 290°F. and for curing times of from one half to one and a half minutes depending upon thickness of section and other factors. Samples molded from this type and some other types of molding compound produced by this and closely related processes are shown.

At the other end of the scale would be a black or brown general-purpose material with an impact strength of approximately 0.25 to 0.35. A typical formulation of such a compound is as follows:

Wood flour	1000 pounds
SYNCO 721 (100% solids basis)	1000 pounds
Nigrosine	10 pounds

No lubricant is required, and none should be used.

The mix is precipitated with precipitant "K" at a temperature of approximately 85°F. Steam is then blown into the mix to raise the temperature to approximately 120°F. whereupon the fiber and resin separate from the aqueous substrate. The water layer is then decanted.

This operation is best performed in a dough mixer or sigma-blade mixer. The doughlike material will have a moisture content of approximately 30% and may be extruded directly without additional predrying. These compounds yield molded pieces having characteristics in line with generally accepted general-purpose phenolic molding powders. Impact strengths are, however, somewhat higher than average.

Modification

In the case of the ivory compound above the properties may be modified in various ways. Acid-stable dyestuffs and pigments may be used to obtain a complete range of colors. Of major importance is the modification of the material with elastomers such as Hycar and Neoprene to increase impact strength. It should be noted that impact strength as measured by the standard Izod or Charpy instruments is a very poor measure of the "banging around" resistance which is what we are really after for most applications. The most important property which a plastic must have to withstand mechanical shock is plastic deformability combined with reasonable transverse or flexural strength. The ability of the material to be deformed without rupture determines the amount of force required to break the piece. The notched bar which is broken in the impact testing machine totally eliminates the factor of plastic deformation and it is this fact, primarily, which is responsible for the poor and often negative correlation between standard impact tests and, for example, drop tests or actual service tests. The latter are far more reliable, and I know I speak for many other plastics engineers when I say that I look forward to the day when impact testing of plastics will be put on a realistic basis.

Beater Addition Resins in Building Materials

The plywood surfacing papers which have been previously mentioned in these communications have been extensively developed commercially during the past year. New and important uses for them have begun to emerge. It has been found, for example, that soft boards such as are used for insulation and interior wall construction cannot be ordinarily used for final finish since the surfaces are too soft, have too little resistance to water, and do not take paint sufficiently well to provide a wholly satisfactory surface.

Since the beater addition resins which are employed in the manufacture of these surfacing papers cure at temperatures of from 200 to 300°F. under little or no pressure, it has been found possible to hot-press them to soft boards directly with only slight compression of the board taking place. The surfacing paper although not ordinarily self-bonding has a phenolic resin glue line applied to one side which makes it possible to bond these materials in the manner described. Since the overlay surface is dense and tough, and since a moderate amount of densification of the surface of the soft board occurs during hot-pressing, the final product is surprisingly resistant to damage by blows which would ordinarily gouge the surface of the boards very seriously. It is probable that this development can greatly increase the scope and utility of soft boards in the construction industry.

Railroad Cars

These plywood surfacing papers are coming rapidly into use for special service applications, notable among which is their use in the revolutionary "Unicel" freight car which has been announced in the past three months. In this application masking types of overlay papers are employed in two different ways. In one case they serve primarily to provide a paintable surface which effectively masks the grain of the plywood underneath. More importantly, however, the masking papers serve as a cushion between the plywood and the dense plastic sheets which in this case are either impregnated or beater addition plastic papers such as are described in the "Beater Addition Process for Producing Laminated Papers."†

Chemically Resistant Papers

In a forthcoming paper entitled "Super Wet Strength by the Beater Addition Process," which we are presenting at the National TAPPI Meeting in February, we will discuss the specifications and formulations for the manufacture of papers possessing not only an extremely high order of wet strength (35–130% of treated dry strength), but will also describe some of their rather surprising chemical resistances. It has been found, for example, that kraft papers containing approximately 25% of these beater addition resins stand long immersion in strong mineral acids such as sulphuric and hydrochloric acid with loss in bursting strength of the order of from 5 to 20%. The untreated papers under the same conditions are, of course, completely destroyed. Similar results, although not to quite as high a degree, are obtained by saturation of paper by water-soluble phenolic resins followed by drying and curing. Papers produced in this manner, however, are extremely stiff and brittle whereas the beater addition treated sheets are perfectly tough, flexible, and resilient, and may be folded and fluted and otherwise manipulated in the cured state. A wide variety of commercial filter papers have been produced by the use of these beater addition resins, and the list of applications for these is growing rapidly. It has been found, for example, that slurries of hydrated lime may be filtered on rotary filters using these papers as the filter medium with negligible loss in efficiency over extended periods of time. It is well known that such slurries are among the most difficult materials to clarify, and all other types of filter papers swell and plug almost instantly when subjected to this service. This application will be discussed in detail in the forthcoming paper.

A great deal of development has also materialized in the production and application of elastomer-containing papers and boards. Bascom‡ has published data during the past year discussing the use of these particular beater addition phenolics in conjunction with the deposition of elastomer latices upon papermaking fibers, and the manufacture of paper therefrom. These procedures have been perfected to the point where production of high rubber content products on

‡ Bascom, R. C., "Phenolic Resins in Paper Modified by Acrylonitrile Rubbers." Presented at the Paper-Plastics Conference sponsored by TAPPI at Syracuse, N. Y., October 19–20, 1950.

paper machines is substantially free of the risk of contaminating the mill equipment.

The present paper is offered as a progress report rather than as an attempt to discuss specific techniques for producing these rather unusual materials. We will present more detailed information on some of these subjects in subsequent papers, and our organization is most happy to cooperate in the solution of specific problems. There are, however, many cases in which new products have been developed in cooperation with the research organizations of paper mills which we are therefore unable to discuss publicly.

M. G. Lyon, *Recorder*

New England

The New England Section held its third meeting of the 1950–1951 season on January 19, 1951, at the Hotel Roger Smith, Holyoke, Mass. About 125 members and guests were in attendance. Robert Proctor, Chairman, presided and turned the meeting over to Miss Helen U. Kiely, Program Chairman for this meeting, which dealt with Quality Control.

Miss Kiely introduced representatives from companies showing various paper testing machines.

R. Betts of W. & L. E. Gurley & Co., made a few remarks about their densometer. He stated that an elastic gasket was required by TAPPI on all densometers since 1945. New type cylinder tops for the open-top instruments are now available. Due to impending shortages he urged that needed equipment be ordered without delay. He also showed the new stiffness tester.

Benjamin Astley, Asst. Chief Engineer of B. F. Perkins, Inc., said the biggest improvement made on the Mullen Tester in recent years is a new type gage which can be used on old testers.

Fred Batchelder of Testing Machines, Inc., said that since 1946 a keen interest developed in the Schopper fold testers and many people now prefer it over the M.I.T. fold tester.

Norman I. Bearse, Vice-President of Champion-International Co., spoke on "What Management Thinks of Quality Control." Management has a deep appreciation of the technical group. He stated that any one of the following duties of management can depend upon the service management gets from quality control.

The duties of management as he outlined them were:

1. Efficient use of the company's equipment in the production of paper.
2. To make sure that the product satisfies the customer's needs and will compete in the prevailing market.
3. The maintenance and housekeeping with relation to company profit.
4. To insure improvement in equipment and product so that we can keep abreast of the times.
5. To arrange for equitable distribution of work hours and fair compensation for effort in production.

Maurice Blew of Strathmore Paper Co. also discussed Quality Control and emphasized the need for analyzing the present product and being aware of customer specifications and maintaining them. The chief tool in doing this work is a control chart with standards and upper and lower limits. A change is made only after a limit line has been crossed.

A. G. Dreis, *Secretary*

Lake Erie

Fifty LEPCA members and guests attended the January 19 meeting held at the Hickory Grill in Cleveland, Ohio.

Captain G. C. Briant, Commanding Officer of the Akron Naval Air Station, made several timely remarks on the role of Carrier Aviation in the present Korean conflict. The Captain also discussed, in a general way, the work now being carried out at the Akron installation in the training of Naval Reserve "week-end" flyers. An interesting discussion followed the Captain's remarks in which the Captain discussed some of the Oriental philosophy which helped explain many of the happenings in the present Korean situation.

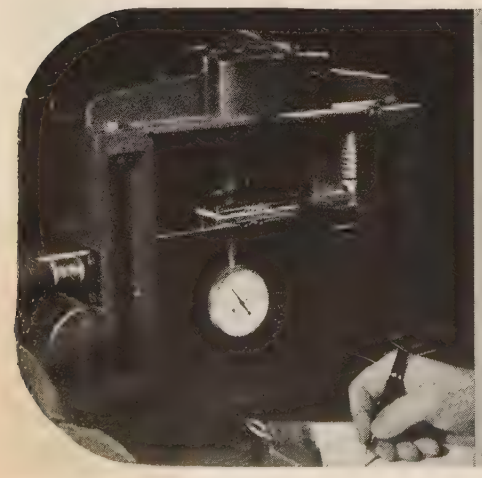
Paul Miessler, the Chief Designer of the Hankins Co., discussed some of the problems involved in designing corrugated containers. Mr. Miessler stated that specialty packaging is rapidly moving into the corrugated container field with special displays involving intricate die cutting, and more decorative printing becoming the rule rather than the exception. The container designer has a wealth of raw materials to work with and in most cases can supply the customers' wants whether they be functional or decorative. Mr. Miessler went through the various steps necessary in the design and production of a corrugated container in order to bring out some of the problems of the container designer. He also gave an interesting historical background on the development of the present corrugated container.

The program for the February 16 meeting was on the subject of "Materials Handling" with several qualified speakers on hand to handle the subject.

Kalamazoo Valley

The 16th annual joint meeting of the Kalamazoo Valley Section and the Michigan Division of the Superintendents Association was held at the Hotel Harris in Kalamazoo, Mich., on January 19. About 350 attended. Dwight Stocker of the Michigan Paper Co. presided as toastmaster. J. J. Harrison of the Michigan Carton Co., Battle Creek, Mich., is Chairman of the Kalamazoo Valley Section and O. W. Callighan of Edgar Bros. Co. is Chairman of the Michigan Division of the Superintendents Association.

A period of silence was maintained in memory of Ralph A. Hayward, former President of the Technical Association, who died just prior to the meeting. With Mike Redmond, Mr.



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Hayward instigated the holding of these joint meetings as a community affair for the benefit of all of the manufacturing employees of the Kalamazoo mills.

The principal speaker was Allen A. Stockdale of the National Association of Manufacturers who talked on "Let's Build a Better America."

On February 1, the Section conducted a symposium on "Pulp and Paper Mill Waste Waters." In this the following presentations were made: "Waste Water Surveys," by E. N. Ross, Lee Paper Co., Vicksburg, Mich.; "Semichemical Pulp Liquor Waste," by D. L. Voigts, American Boxboard Co., Filer City, Mich.; "Sveen Pederson Savealls," by Gordon Hoy, Michigan Carton Co., Battle Creek, Mich.; and "The Effect of Waste Recovery and Treatment Processes on Stream Improvement," by A. J. Palladino, National Council for Stream Improvement, New York, N. Y.

Chicago

The Chicago Section met on January 15, 1951, and conducted a symposium on "The Growing Shortage of Technical Men for the Pulp and Paper Industry."

Participants in this program were: A. H. Nadelman, Professor of Pulp and Paper Technology at Western Michigan College, Kalamazoo, Mich.; Harry F. Lewis, Dean of The Institute of Paper Chemistry, Appleton, Wis.; and C. E. Libby, Head of the Department of Pulp and Paper, New York State College of Forestry, Syracuse, N. Y.

The speakers discussed the growing shortage of trained technical personnel. As an example of what the future may bring, Dr. Nadelman reported that of nine senior students in his department, only three are sure of graduation and working in industry. He painted a darker picture still by stating that a large number of sophomores are enlisting to get a choice of service and thus the supply of students is being cut off at the roots. Dr. Libby corroborated the view that a mere trickle of men will graduate when he informed the audience that of 25 seniors in the Pulp and Paper Department, only five to eight will be available to industry.

New York State College of Forestry doesn't normally take women—two were enrolled during World War II—while Western Michigan College is considering the recruitment of women.

In the research field, Dr. Lewis described the experimental testing program being carried on to develop methods of determining if a man has the required talents for work in pulp and paper. Dr. Libby described their work on making hardwoods into top grade pulps.

A question and answer session followed the formal talks.

R. E. Boedeker, *Recorder*

Delaware Valley

"The Paper Industry's Status in the Rearmament Program" was discussed by Louis T. Stevenson, Economist, American Paper and Pulp Association, as he addressed the members and guests of the Delaware Valley Section at a dinner meeting at the Engineers Club in Philadelphia on January 25, 1951.

At the request of Program Chairman, Dr. Haug, who was unable to be present, the chairman, Dr. Erspamer, reminded the Section of the course in "The Practice and Chemistry of Pulp and Papermaking" offered by St. Joseph's College Paper School.

After the discussion which followed Dr. Stevenson's address, appreciation on behalf of the Section to Dr. Stevenson was expressed by Dr. Erspamer and the meeting was adjourned. Attendance was approximately 55. (Mr. Stevenson's presentation is published elsewhere in this issue.)

Highlights of the Discussion Following Dr. Stevenson's Address

Question: Will there be a large amount of new domestic pulp supply in 1951?

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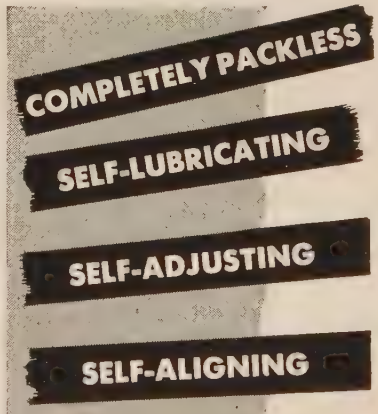

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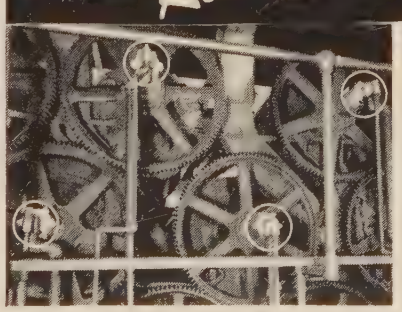

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Dr. Stevenson: Yes, there should be. As I pointed out in my address and if you will look at the chart, the production of U. S. pulp in October, 1950, a peak month, expanded to an annual rate, indicates a potential increase in the production of pulp of about 1,500,000 tons over that of 1950.

Question: What can be expected in the way of imports of pulp this year?

Dr. Stevenson: The supply of foreign pulps to the United States depends a great deal on price regulations and, of course, on the war situation, whether there will be an all-out war or not. A good example of the possible effect of price regulation was the situation in Norway. Norwegian domestic paper prices were frozen below those of the export market and as a result, her supply did not meet her demand, even to the point where she did not have enough paper for income tax blanks.

Question: Of the expected new pulp production, how much would you estimate to be market pulp?

Dr. Stevenson: I do not know. I have not studied that particular angle. I know that in October we had a demonstrated pulp capacity of one-and-a-half million tons greater annually than was produced in 1950. I do not know how much of this is market wood pulp, but I believe that at least some of it probably is available to the market.

Question: What has been accomplished in investigating a greater utilization of waste paper for the manufacture of paper and paperboard?

Dr. Stevenson: The National Paperboard Association's members use most of this waste paper. During World War II, 35% of available waste paper was used for the manufacture of paper and paperboard, or 40% after deducting overseas military packaging.

The ratio of waste paper to virgin pulp usage in the United States is very large in comparison to that of most European nations. The amazingly large per capita consumption of paper products in the United States, approximately 380 pounds per capita, is in part due to this. France, for instance, consumes only 75 pounds per capita.

Empire State

Western New York

The regular meeting of the Western New York District of the Empire State Section took place on Wednesday, February 7, at the Prospect House, Niagara Falls, N. Y. Approximately 50 members and guests enjoyed the excellent dinner and program presided over by Irving Earle, Upson Co., Lockport, N. Y., chairman.

Among the guests present at the meeting were S. G. Stapley, chairman of the Niagara Branch of the Canadian Pulp and Paper Association; W. E. Dyke, J. Delaney, and R. Thompson, all members of the Executive Committee of the Niagara Branch of CPPA Technical Section.

H. P. Bailey, International Paper Co., Niagara Falls, introduced the speaker of the evening, Prof. C. E. Libby, New York State College of Forestry, Syracuse, N. Y., who discussed "The Educational and Development Program at New York State College of Forestry." Professor Libby's remarks follow:

"The New York State College of Forestry is the only Forestry College in this country which has a course for training students for the pulp and paper industry. It was founded in 1911, and the pulp and paper course was introduced into the curriculum in 1920. New York State College of Forestry is thus the second institution in the United States to give instruction in papermaking, being preceded only by the University of Maine which inaugurated this type of training in 1912. Since that time, the Institute of Paper Chemistry was founded in 1929, and Western Michigan College of Education and Lowell Textile Institute have added paper courses in the last five years.

"The New York State College of Forestry has now the largest student body engaged in training for the pulp and paper field. Of the 795 in the college, about 20% are studying papermaking courses. The distribution of the students by classes are as sophomores, 27; as juniors, 23; as seniors, 26; as graduates, 22; and as freshmen, estimated to be 50. As the freshman year is the same for all forestry courses, the exact number who will follow pulp and paper cannot be determined.

"Among the graduate students are two girls, one on an industrial fellowship, and one from China. Other graduate students are distributed one each from the Philippines, Paraguay, China, Burma, Spain, Turkey, and France.

"The increased demand for technically trained men for the pulp and paper industry has caused other institutions to add such

Left to right: S. G. Stapley, H. P. Bailey, C. E. Libby, and I. V. Earle

training to their regular curricula. These institutions will graduate about 40 this year. Some idea of the demand for graduates may be shown from the fact that for the 26 graduates from New York State College of Forestry this June, there have been 106 positions offered them.

"The papermaking curriculum has a forestry foundation and courses taken in the freshman and sophomore years are largely forestry and basic science training. This makes it possible for the student to obtain an appreciation of the problems of growing and managing the forest raw materials and a fundamental knowledge of wood anatomy, fiber structure, and the chemistry of cellulose and wood. Papermaking courses are introduced in the junior year. The distribution of courses in the curriculum are as follows: Cultural, 15 hours or 10%; Forestry, 15 hours or 10%; Drawing, Mathematics, and Engineering, 28 hours, or 18%; Fundamental Physics and Chemistry, 44 hours or 30%; Pulp and Paper, 38 hours or 25%; and Electives, 10 hours or 7%. The total hours are 150, which makes it one of the most difficult courses offered at the college.

"At the present time the curriculum is in a state of flux as the college will become part of the State University of New York and more emphasis will be placed on Cultural courses and less on scientific training. This will probably involve a shift to about 25% Cultural courses in place of the present 10%. Pulp and Paper courses will remain about the same but training in other fields will be somewhat reduced. The total number of hours will likewise be reduced.

"During the last year a course in Paper-Plastics has been added to the curriculum and this is attracting wide attention with graduates in great demand. This course has 13 hours in plastics with an additional 6 hours for graduate students.

"A Management and Sales Option course in pulp and papermaking is also planned with 15–30 hours of courses, mostly selected from the College of Business Administration such as Accounting, Personnel Management, Sales Management, Labor Relations, Psychology, etc.

"The Pulp and Paper Building of the College of Forestry was opened in 1937 and has 25,000 square feet of floor space. This building or pilot plant contains facilities to reproduce all mill operations. Among these are a combination paper machine to make fourdrinier or cylinder papers which has a 52-inch wire and a capacity of about 1000 pounds per hour. It has a speed range of 5–500 feet per minute.

"The College of Forestry carries on a full program of research and has two full-time workers with doctor's degrees on fundamental research. One of these men is working on plastics and one on lignin chemistry. Eight full-time workers plus additional staff members are engaged in applied research. During World War II many research projects were carried out for the government. One of these, a redwood bark project was so successful that the college operated it on a commercial basis on a 24-hour, 7-day week program.

"At the present time a hardwood pulping project is under way and shows good commercial possibilities. This project, also known as the Chemigroundwood process, is being carried out for a cooperative research group—Eastern States Pulpwood Research Association—supported by 15 mills and the State of New York. The mills interested include several Southern and Canadian firms.

"As the New England and New York States have only an estimated 178,000,000 cords of softwood and have 315,000,000 cords of hardwood, the commercial utilization of hardwood would prove a valuable source of pulp."

RECENT BOOKS

Materials of Construction for Chemical Process Industries. By James A. Lee, Southwestern Editor of Chemical Engineering. McGraw-Hill Book Co., New York. 1950. Cloth. 6 × 9, 468 pages. $6.50.

For many years this reviewer has felt that Jim Lee should write a book. Whenever a problem in corrosion or materials of construction appeared it has been natural to ask Mr. Lee about a possible solution. He either had it or could report on what was known about it very soon.

Mr. Lee took a considerable interest in the pulp and paper industry and for a number of years was Chairman of the TAPPI Materials of Construction Committee.

The present volume is prepared somewhat like an encyclopedia covering over 300 chemicals and combination of chemicals, mentioned alphabetically. Corrosion problems encountered in such process industries as sulphite and sulphate pulping, soap, etc., are discussed. Emphasis, throughout the book is on materials of construction that have been found by operating experience to be the most serviceable and economical in commercial-size plants.

Each chemical item generally opens with a brief introduction followed by sections on production, handling, and packaging. The first section is subdivided into brief discussion of the metallic and nonmetallic materials used in production. This is followed by a description of the process in which the materials of construction of each piece of equipment are indicated. The second section deals with the corrosiveness of the chemicals. The section on packaging deals with the materials of construction used for the shipping containers. At the end of the book is a Directory of Materials, giving the manufacturers' names and a description of the material.

R. G. Macdonald

Unit Operations. By George Granger Brown and eleven co-authors. New York. John Wiley & Sons. 1950. Cloth. $8^5/_8 \times 11^1/_4$, 612 pages, 568 illustrations. $7.50.

Dr. Brown and his collaborators are, for the most part professors of chemical or metallurgical engineering at the University of Michigan.

Modern practice and equipment are emphasized as well as mathematical interpretations. The book has been prepared as a textbook for chemical engineering students and although a knowledge of physics and calculus is helpful it is not entirely necessary for an understanding of the text.

The text deals with such operations as screening, size reduction, properties of fluids, flotation and sedimentation, measuring flow of fluids, pumping, gas flow, filtration, separation of phases, heat transfer, evaporation, agitation, and drying. By study of these operations the engineer is guided toward the successful design, construction, and operation of a plant for any new process which may be required.

A Primer of Engraving and Printing. By Harry A. Groesbeck, Jr., New York. Colton Press, Inc., 1950. Paper. $4^3/_4 \times 7$, 174 pages. $2.50.

The late Harry Groesbeck, who died in 1950, was a master of reducing complexities to simple expositions by use of the written word. The Primer, in its great simplicity, serves as a monument to his kind of go-giverness. Mr. Groesbeck reported to the superintendent of a printing plant in New York City in 1896 to begin employment and to learn the printing business. He was a craftsman throughout the rest of his life.

In this volume he describes the three printing processes, letterpress engraving, plate-making for lithography and gravure, typesetting, electrotyping and stereotyping, presses and printing, paper, ink, and "Which is the best process?" He writes as a practical printer and engraver to readers who wish to have practical explanations.

Copies of all books reviewed in this issue may be obtained from the Book Dept., TAPPI, 122 E. 42nd Street, New York 17, N. Y.

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M2-51. For Sale: Williams apparatus paper testing oven in perfect condition. Used less than a week.

Instrumentation Studies. LXII. Erasability of Paper

II. Progress Report on a Study of Erasability

W. A. WINK and LEONARD R. DEARTH

This progress report presents the first phase of experimental work on erasability. An abrading machine for research purposes was designed and constructed; the unique features incorporated in the design of this machine provide (a) a wide range of flexibility and (b) a means for erasing relatively large surfaces (approximately 5 by 5 inches) of paper. Twenty-three different writing papers have been abraded and tested to determine some of the effects of erasure on the physical properties of paper. The physical tests which have been made on abraded and unabraded samples of paper include weight, caliper, reflectance (R_∞ and R_0), gloss, and writing quality.

A PROBLEM which the Subcommittee on Instrumentation Research of the American Paper and Pulp Association had on the agenda for investigation prior to World War II concerns the measurement of the nebulous property of paper referred to as erasability. At the outset of this investigation, the committee recommended that the initial phase of this study be directed toward an investigation of specific abrasion testers. However, on returning to this problem after the war, the original plans for the investigation were modified to encompass a more fundamental study of the problem. Other investigations of the past have been, as a rule, quite limited in scope; in particular, the small size of the erased portions of specimens restricted the type of tests which could conveniently be made. In an effort to circumvent this limitation, it was believed desirable to construct an abrader which would erase a sufficiently large surface to permit evaluation of the changes in the physical properties of the paper caused by erasure.

In consideration of the various means for erasing a relatively large surface, attention was directed toward the possibility of employing a shaper (the type commonly used for small work in machine shops), modified in such manner that it could be used in this special application. Since a small shaper, possessing many of the desirable features required in a study of this kind, was already available to us, it seemed desirable to make the necessary modifications to convert this shaper into an abrading machine. A description of this machine, as well as the preliminary data obtained for a series of different writing papers, are presented in the following sections of this report.

DESCRIPTION OF THE ERASING MACHINE

Photographs of the shaper, which was converted into an erasing machine for this investigation, are shown in Figs. 1 and 2. The fan which is shown in Fig. 1 was omitted in Fig. 2 in order to avoid obstructing a view of the mechanism attached to the right side of the shaper. The principle of operation involved in this machine is one in which the reciprocating motion of the shaper ram causes a circular erasing wheel to move back and forth over the surface of the paper. Through the action of a pair of one-way brakes, the abrading wheel is locked, to prevent rotation, on the forward stroke; on the back stroke, which is the nonerasing stroke, the brakes are released and allow the wheel to rotate freely. In order to produce abrasion over a relatively large surface of the paper, this abrading machine is equipped with an automatic cross-feed mechanism. This mechanism is synchronized with the nonerasing stroke and causes the sample to move in a direction perpendicular to that of the erasing wheel in such a manner that successive erasing strokes are made on a different area of the paper. Both the stroke and the distance of travel of the cross feed are adjustable, so that the machine can abrade surfaces up to approximately 5 inches square. A detailed description of the mechanism of the abrading machine is given in the following paragraphs.

The rotary motion of the motor-driven mechanism, enclosed in the housing *1* of the shaper, transmits a reciprocating motion to the ram *2*. By design, the enclosed mechanism drives the ram at a constant speed throughout the forward travel of the ram. This desirable feature of the drive was taken into account in the design of the erasure assembly and is the reason for utilizing the forward stroke as the erasing stroke. The reciprocating motion of the ram is transmitted to the erasing wheel through the bar *3*, and the clevis *4*; the latter is attached to the bar by means of a simple bearing *5*. The brace *6* was added to the assembly after the machine was put into operation for the purpose of damping out a small vibration at the lower end of the bar *3*. Trial tests without the brace indicated that a small vibration at the end of the bar seriously affected the uniformity of the abraded surfaces.

Since the vertical thrust of the eraser on the sample, during an erasing stroke, is affected by the vertical position of the bearing *5*, the position of this bearing is adjusted to lie in the same horizontal plane as that of the sample. Thus, the vertical thrust, during an erasing stroke, is the same as the static thrust; the latter is simply the force exerted by the complete eraser assembly (complete assembly of the clevis including the abrading wheel, brakes, brush, etc.) as measured at the center of the shaft *7*. The vertical thrust of the eraser assembly for this abrading machine is 555 grams with the adjustable weight *8* located in the position shown in the photographs; without the additional weight *8*, the vertical thrust of the erasing wheel on the sample is 370 grams.

The abrading wheel *9* is mounted on a $^5/_8$-inch diameter shaft; the ends of this shaft are turned down to

W. A. WINK, Member TAPPI; Technical Associate; LEONARD R. DEARTH, Technical Assistant, The Institute of Paper Chemistry, Appleton, Wis.

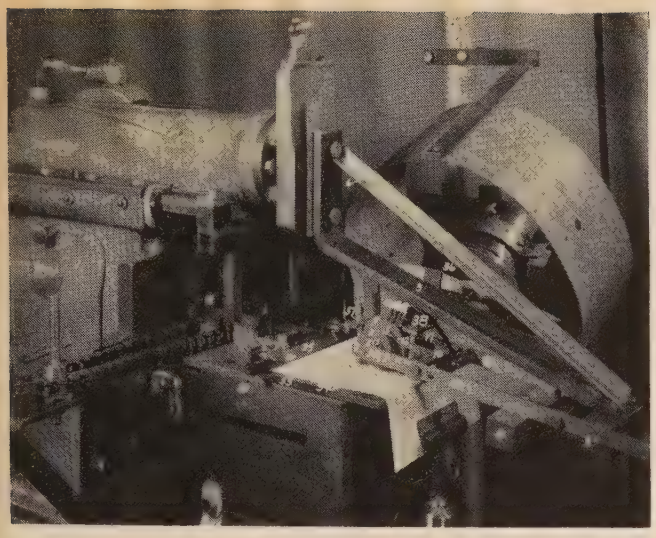

Fig. 1

fit into the $^3/_{16}$-inch diameter bearing *10*. The abrading wheel is held in a fixed position on the shaft between two plastic washers *11* and *12* and the nuts *13* and *14*. These nuts are drawn up tight so that the abrading wheel, the two plastic washers, and the shaft are forced to rotate as a unit.

The two plastic washers *11* and *12* also serve as drums for the one-way brakes. A brake band *15*, consisting of a thin metal ribbon having a thickness of 0.002 inch, is wound around each plastic drum approximately $1^2/_3$ turns; one end of this band is anchored securely to the bottom side of the cross member *16* and the other end of the band is attached to the spring *17*. In operation, the brake band firmly grips the plastic drum during the forward stroke of the ram, to prevent rotation of the erasing wheel; on the back stroke of the ram, the small tension of the spring permits the eraser to roll freely.* The construction and operation of the two brakes, one on each side of the abrading wheel, are identical.

Most of the details concerning the construction of the automatic cross feed, which provides a means for abrading a relatively large surface of paper, may be seen by referring to Fig. 2. By disengaging the table *18* from the cross-feed screw *19*, most of the original cross-feed equipment of the shaper was utilized in this special application. The power-driven ratchet *20*, formerly used to move the table *18* by means of the intermediate cross-feed screw *19*, is now employed to move the table by means of the chain *21*. The power supplied to the ratchet is transferred to the chain through the two beveled gears *22* and *23*, the shaft *24*, and the sprocket *25*. The action of the ratchet is synchronized with the reciprocating motion of the ram in a manner which causes the chain to move with the back stroke of the ram; on the forward stroke of the ram, the chain and the table remain stationary. The distance of travel of the table for each stroke of the ram may be adjusted by changing the position of the connecting link between the ratchet and the eccentric drive *26*. Because of the ratchet, the range of this adjustment is limited to five definite positions; these five positions give a table displacement of 0.075, 0.150, 0.225, 0.300, and 0.375 inch, respectively. In order to produce uniformly abraded surfaces, the width of the erasing wheel must be an integral multiple of the table displacement. For the work covered in this report, the ratchet was adjusted to displace the table 0.150 inch per stroke. By cutting the abrading wheels, which were originally $^1/_2$ inch wide, to a width of 0.45 inch, three complete erasing strokes displaced the table the full width of the wheel. Failure to adjust the width of the abrading wheel to an integral multiple of the table displacement gave rise to a condition which caused irregularities in the abraded surface.

The attachment *27*, which serves as a means for engaging the table to the chain, consists of a key way containing a rectangular piece of key stock. The length of this key is slightly less than the distance between the two halves of the chain at this point. With the key engaged in one of the slots in the back half of the chain, the table moves to the left until it has reached a point where the post *28* contacts and moves the arm *29* forward to engage the key in a slot in the front half of the chain. The table then moves to the right until it reaches a point where the post *30* contacts the arm *31* and moves the key into a slot in the back half of the chain. This cycle of operation is repeated automatically for any desired number of strokes.

By complying with certain limiting conditions, the width of the abraded surface of the sample may be varied by adjustment of the spacing between the two contacting posts *28* and *30*. The adjustment of the position of these posts is a critical one; the spacing must be such that the slots in the two halves of the chain are exactly opposite each other when the key is disengaged from one half of the chain and engaged in the other half. The frequency of occurrence of alignment is governed by the size of the chain and the displacement of the table at each stroke of the ram. For a table displacement of 0.150 inch, the slots in the chain appear directly opposite each other on every tenth stroke of the ram. Since the table travels a distance of $1^1/_2$ inches for every ten erasing strokes, the position of the contacting posts *28* and *30* must be adjusted to erase surfaces $1^1/_2$, 3, or $4^1/_2$ inches wide.

The total number of erasing strokes is registered on a predetermining counter *32*. This counter is equipped

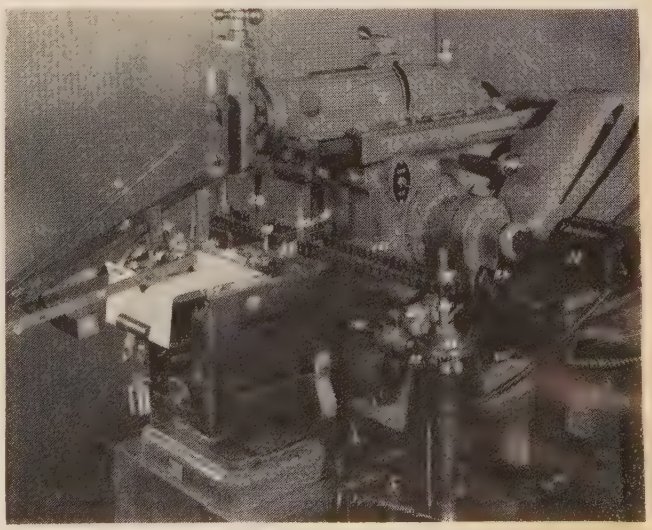

Fig. 2

* This type of "continuous ratchet" was employed by the Internationa Paper Co. in their development of an erasure tester a number of years ago.

Table I. Preliminary Data on Reproducibility

Load	Strokes[a]	Abrasion wheel no.	Weight loss, mg.	Caliper difference, in.	Reflectance Before R_∞	Reflectance Before R_0	Reflectance After R'_∞	Reflectance After R'_0	$R_0 - R_0'$
				Sample 16					
370	162	0	115.8	0.00070	76.0	70.2	75.4	63.6	6.6
370	162	0	114.0	0.00080	76.1	69.9	75.5	62.3	7.6
555	102	0	88.9	0.00051	76.0	69.8	75.3	65.0	4.8
555	102	I	106.1	0.00039	76.0	69.4	75.7	64.6	4.8
555	102	II	104.5	0.00050	76.1	69.8	75.2	66.3	3.5
555	102	III	99.0	0.00064	76.0	69.7	75.4	64.1	5.6
				Sample 17					
370	96	0	54.7	0.00022	83.2	70.7	82.2	66.3	4.4
370	96	0	42.3	0.00000	83.1	70.3	82.0	66.3	4.0
555	90	0	69.1	0.00016	83.0	71.0	82.0	65.0	6.0
555	90	I	78.3	0.00040	83.3	71.9	82.2	65.6	6.3
555	90	II	105.5	0.00059	83.1	71.4	82.0	62.3	9.1
555	90	III	96.4	0.00075	83.0	70.4	81.9	63.2	7.2
				Sample 19					
370	116	0	65.7	0.00012	85.0	74.3	83.6	69.5	4.8
370	116	0	60.9	0.00023	85.0	73.9	83.9	69.8	4.1
555	105	0	77.1	0.00030	84.8	74.3	83.7	68.9	5.4
555	105	I	91.4	0.00058	84.8	74.0	83.8	65.5	8.5
555	105	II	85.8	0.00042	84.4	73.7	83.1	67.2	6.5
555	105	III	93.9	0.00051	84.5	74.3	83.3	67.6	6.7

[a] This is the number of strokes over any given point in the erased area (not the total number of strokes over the whole area).

with a relay and may also be used to stop the motor whenever the counter reaches the number of strokes previously set on the counter wheels.

A piece of plate glass *33*, 1/4 inch thick, and securely anchored to the table of the shaper, serves as a base for the paper specimen *34*. One end of the specimen is held in place by means of a simple clamping device *35;* the other end is attached to a 200-gram load which supplies sufficient tension to keep the specimen in place.

The surface of the specimen and the abrading wheel are kept clean and free of debris by means of the fan *36* and the brushes *37*, *38*, and *39*. Debris, caught in the surface face fuzz of the specimen, is dislodged by the sweeping action of the two camel's hair brushes *37* and *38*, and is carried away in the stream of air produced by the fan. Similarly, any fibers or debris lodged on the surface of the wheel are loosened by the brush *39* and are also carried away by the air from the fan. The brush *39* was cut from a suede shoe brush.

In our first attempts at cleaning the surface of the specimen, an ordinary office fan and a small vacuum cleaner blower were tried and rejected. The office fan was rejected because the velocity of the air stream was too low to remove the heavy particles produced in abrasion, and the blower was rejected because it raised the temperature of the air stream by approximately 2.5°C. Since it was planned to abrade the paper specimens in an atmosphere conditioned to a constant temperature and relative humidity, the increase in temperature was objectionable because it also lowered the relative humidity appreciably.

A fan having the desirable characteristics for this application is shown in Fig. 1. By mounting an 8-inch low-pitch model airplane propeller to a small vacuum cleaner motor, sufficient air velocities could be obtained to keep the surface of the sample clean. Because of its relatively high efficiency, the propeller introduced no significant change in the temperature of the air (the temperature change of the air entering and leaving the fan was no greater than 0.2°C.). In checking the air velocity required to keep the sample clean during abrasion, it was found that a velocity in the neighborhood of 2800 f.p.m. was required for those papers on which an appreciable amount of surface fuzz was developed. Air velocities somewhat less than 2800 f.p.m. could be used for the papers on which a relatively small amount of fuzz was produced by erasure.

PROCEDURE

Following construction of the abrading machine and a series of trial tests, during which the machine was adjusted to give uniformly abraded surfaces, the preliminary phase of the erasability problem was undertaken. The objective of this phase of the investigation included an evaluation of the changes in the physical properties of the paper caused by erasure. The properties evaluated were weight, caliper, gloss, reflectance (R_∞ and R_0), and writing quality.

Twenty-three samples of paper, supplied by manufacturers of the writing paper industry, were abraded and tested in this study. When possible, these samples were supplied to us in the form of small rolls so that the specimens for erasure could be obtained from a narrow strip along the machine direction of the paper. All the erasures and the physical tests which would be affected by temperature and relative humidity were made in a room conditioned to a relative humidity of 50% at a temperature of 75°F.

The procedure employed for abrading the samples and obtaining the physical data was the following: After conditioning the samples to the atmosphere of the humidity room, aqueous ink lines were drawn on the specimens with a special rotary pen, developed and described by Schur and Levy (*1*). This pen provided a means for applying the ink lines under reproducible conditions and eliminated, to a large degree, the many variables inherent in methods employing a common steel or draftsman's pen. Briefly, this pen consists of a rectangular carriage supported by three small wheels. One of the wheels has a fixed circumferential slot of definite width and depth which holds the ink and serves as the pen. As the pen is drawn over the paper

Table II. Influence of Wear of the Abrading Wheel

Specimen	Weight loss, mg.	Caliper difference, in.	Reflectance					Gloss				
			Before		After			Before		After		
			R_∞	R_0	R'_∞	R'_0	$\lvert R_0 - R'_0 \rvert$	In	Across	In	Across	Ratio
					Sample 2							
1	18.9	...	80.1	65.6	78.5	64.3	1.3	12.7	11.3	33.0	17.2	2.09
2	26.5	...	79.9	66.4	78.6	64.0	2.4	14.4	11.5	39.3	20.1	2.29
3	27.1[a]	...	80.0	66.2	78.4	63.3	2.9	12.6	10.6	32.0	18.1	2.16
4	18.4[a]	...	80.1	65.1	78.6	63.9	1.2	12.1	10.1	32.8	18.6	2.32
					Sample 19							
1	93.5	0.00041	87.0	77.2	85.9	71.1	6.1	40.4	35.2	15.0	11.1	0.35
2	81.8	0.00052	86.9	77.1	85.9	71.2	5.9	39.9	33.2	19.1	12.1	0.43
3	83.2	0.00041	86.6	77.0	85.7	71.5	5.5	40.0	33.0	15.7	11.1	0.37
4	92.4	0.00039	86.8	77.5	85.9	71.3	6.2	44.5	36.9	15.8	11.5	0.34
5	82.4	0.00030	87.0	77.6	85.9	72.3	5.3	44.6	36.4	15.5	11.4	0.33
6	98.6	0.00048	86.9	78.4	85.6	71.7	6.7	54.7	46.6	15.8	11.5	0.27
7	106.1	0.00057	86.9	77.8	85.8	70.4	7.4	43.5	36.1	15.7	11.7	0.34
8	105.4	0.00049	86.9	77.1	85.8	69.7	7.4	40.3	33.4	16.1	11.4	0.37
9	96.9	0.00040	88.0	77.6	86.0	71.3	6.3	57.0	46.5	15.0	11.2	0.25
10	104.4	0.00045	86.7	77.0	85.4	69.1	7.9	39.6	37.1	15.5	11.1	0.35
11	96.8[a]	0.00039	86.9	77.1	85.9	70.5	6.6	42.5	35.4	15.5	10.9	0.34
12	74.2[a]	0.00035	86.9	77.8	85.7	72.4	5.4	49.8	41.6	18.4	11.7	0.33
13	80.8[a]	0.00044	87.0	77.6	85.7	72.4	5.2	43.5	34.3	17.2	11.5	0.37
14	81.1[a]	0.00045	86.8	78.0	85.8	73.4	4.6	54.0	45.5	16.9	11.6	0.29

[a] The abrading wheel had worn down to or past the limiting diameter in the abrading of these specimens.

at a uniform velocity by means of a small motor, the ink is deposited on the paper. A commercial ink* was used in the work done thus far. Following application of the ink lines, the specimens were again conditioned to the atmosphere of the humidity room for a minimum period of 24 hours prior to erasure.

"Calibrase" abrasion wheels, No. CS17F, manufactured by the Taber Instrument Co., were used as the eraser and the abrading machine was adjusted to erase surfaces approximately 3 inches square.

Following abrasion of a specimen, two pieces, each $2^1/_2$ inches square, were accurately cut from the specimen—one from the central portion of the abraded area and the other from a portion of the original sample. The latter was always cut from a region of the sample adjacent to the erased surface and lying in the same machine-direction zone of the paper. The specimens obtained in this manner were subsequently tested; the weight, caliper, reflectance, and gloss were obtained in the order mentioned. The thickness measurements were made with a Federal compressibility gage having a spindle with a diameter of 5 mm. and under a load of 7 p.s.i.; the reflectivity measurements were made on the Bausch and Lomb opacimeter and the G.E. recording spectrophotometer (only the values in Table I were obtained with the B & L opacimeter); the gloss measurements were made with a special low angle glossmeter which was constructed for use in this study from the parts of a goniophotometer. In this instrument, the specimen is illuminated and viewed at an angle of 9° with the surface of the paper. Illumination is supplied by a 50-candle power single-filament lamp and the light reflected from the surface of the sample is measured by means of a Weston photronic cell and a suitable galvanometer circuit. The incident beam contains a rectangular aperture which limits the size of the illuminated spot of the sample to a length of 1 inch and to a width of approximately $^1/_2$ inch. This special glossmeter employs no lenses in the interest of obtaining a small spread of angles in the incident beam. Accordingly, the intensity of the light reflected by a specimen is low, and a galvanometer of good sensitivity is employed. In standardizing the instrument and adjusting the "hundred setting" on the galvanometer, a piece of black Carrara glass is placed over the sample opening and a neutral filter is held in the path of the reflected beam. By standardizing in this manner, the galvanometer scale is spread by a known factor of approximately 10, since the neutral filter is removed while measuring the gloss of the paper.

For the purpose of checking the writing quality of the paper after erasure, ink lines were again drawn on the abraded specimens, following the physical measurements described above. For record purposes, photographs were obtained of the specimens having ink lines drawn before and after erasure.

* Sanford's Premium Writing Fluid, manufactured by the Sanford Ink Co.

RESULTS AND DISCUSSION

Before making comparative tests on the 23 different papers, three of the samples were abraded with four different Calibrase wheels in order to check the reproducibility of the abrasion. These results are presented in Table I, where the first column presents the vertical thrust of the abrading wheel on the sample; the second, the number of abrading strokes the specimens received; the third, our designation of a particular wheel; the fourth, the weight lost by a specimen $2^1/_2$ by $2^1/_2$ inches in size; the fifth, the difference in the caliper before and after abrasion; the sixth and seventh, the R_∞ and R_0, respectively, of the specimen before abrasion; the eighth and ninth, the R'_∞ and R'_0, respectively, of the specimen after abrasion; and the tenth, the difference in R_0 values obtained before and after abrasion. The choice of number of strokes for the two different loadings of the wheel was based on an earlier experiment in which specimens containing ink lines were abraded. The number of strokes designated in Table I is that found necessary to remove the ink lines in the previous experiments. Upon examination of the data obtained with a load of 555 grams, it will be seen that the amount of material removed from the three samples by the different abrading wheels is quite irregular. Specimen variation seems to have overshadowed any small effects the abrading wheels themselves might have introduced. Very poor correlation between caliper and weight loss was observed. Many

of the irregularities seen in the values of thickness were in all probability caused by fuzz and small bundles of fibers on the surface of the abraded specimens. In general, it will be observed that the differences in the R_0 values are in fair agreement with the weight loss values.

Table III. Description of Samples and Degree of Erasure

Sample	Description	Number of Strokes[a] In	Number of Strokes[a] Across	Weight loss, mg. In	Weight loss, mg. Across
2	Blue print, 50% rag	675	690	75.3	71.7
3	Bond, 75% rag	1350	1425	51.7	69.8
4	Bond, 75% rag	1005	1190	70.9	61.1
5	Bond, 25% rag	330	342	92.3	84.7
6	Bond, 50% rag	1350	1290	79.7	66.5
7	Bond, 75% rag	1350	1290	85.6	68.3
8	Bond, 100% rag	1500	1500	85.7	85.4
9	Ledger, 25% rag	675	600	66.2	60.8
10	Ledger, 50% rag	390	420	55.3	60.0
11	Ledger, 75% rag	480	360	72.6	72.3
12	Ledger, 100% rag	435	434	75.3	67.8
13	Ledger	252	165	83.8	55.8
14	Chart	192	150	76.0	72.9
15	Ledger	255	201	76.7	70.4
16	Bond	95	75	117.0	60.8
17	Duplicator	66	66	82.3	70.4
18	Form	300	237	85.0	71.7
19	Label	87	57	63.0	80.4
20	Drawing, 25% rag	..	213	..	71.2
21	Bond, 100% rag	..	321	..	92.2
22	Ledger, 100% rag	..	525	..	81.0
23	Ledger, 50% rag	..	261	..	71.0
24	Bond, 50% rag	..	222	..	72.9

[a] This is the number of strokes over any given point in the erased area (not the total number of strokes over the whole area).

The Calibrase abrasion wheels supplied by the Taber Instrument Co. are 2 inches in diameter; these wheels are marked on the side, on a $1^3/_4$ inch diameter, to indicate the minimum diameter at which the wheels should be used in the Taber Abraser. As the wheels are worn from a diameter of 2 inches to a diameter of $1^3/_4$ inches, both the pressure of the wheel on the specimen and the area of contact between the wheel and the specimen change. In order to study the effects of such changes on abrasion results, the data presented in Table II were obtained. The two samples selected for this study (2 and 19) had widely different erasing characteristics. A new wheel was employed at the beginning of the erasures of each of two series of specimens. Each specimen of sample 2 was abraded 300 strokes which, for a 3 by 3-inch surface, corresponds to a total of 2000 strokes, and each specimen of sample 19 was abraded 105 strokes which, for a 3 by 3-inch surface, corresponds to a total of 700 strokes. On sample 2, the wheel was worn to its minimum diameter during the abrasion of specimen 3. The remaining specimen (4) was abraded with a wheel having a diameter less than $1^3/_4$ inches. On sample 19, the wheel was worn to its minimum diameter during abrasion of specimen 11. The remaining three specimens (12, 13, and 14) were abraded with a wheel having a diameter less than $1^3/_4$ inches. Both the loss in weight values and the reflectivity values for samples 2 and 19 fail to indicate any significant change in the abrasion results, as the abrading wheels are worn down from a diameter of 2 inches to a diameter of $1^3/_4$ inches. The variations that occur in these values were apparently caused by variations in the specimens. The gloss values obtained with the special glossmeter are presented in columns 9 through 12; the last column presents the ratio obtained by dividing the average of the readings obtained after erasure by the average of the values obtained before erasure. It will be noted that the gloss of sample 2 increased as a result of erasure, whereas that of sample 19 decreased.

The results of the physical measurements on the 23 samples of paper are presented in Tables III, IV, and V. Two specimens of each samlpe (excepting samples 20 through 24) were abraded on the felt side with the same abrasion wheel, one specimen with the erasing stroke parallel with the machine direction of the paper and the other with the erasing stroke perpendicular to the machine direction of the paper. Each specimen was erased with a number of strokes required to remove the ink lines from the surface of the paper. Erasure was considered complete when the lines were almost completely obliterated and only a very small trace of the ink remained. The specimens for which the erasing stroke was parallel with the machine direction of the paper had two ink lines which were also parallel with the machine direction; those specimens abraded in the across-machine direction had two pairs of lines drawn at right angles to each other. When abrading the

Table IV. Effect of Erasure on Reflectance

Sample	Erasure in machine direction: Before R_∞	Before R_0	After R'_∞	After R'_0	$R_0 - R'_0$	Erasure across machine direction: Before R_∞	Before R_0	After R'_∞	After R'_0	$R_0 - R'_0$
2	80.2	66.6	76.7	58.1	8.5	80.5	66.4	76.2	59.7	6.7
3	82.2	67.1	70.1	56.7	10.4	82.3	68.4	71.0	56.3	12.1
4	81.0	63.5	72.2	52.0	11.5	81.3	62.6	75.3	55.2	7.4
5	77.9	67.6	76.1	60.6	7.0	77.6	67.7	76.1	61.9	5.8
6	79.6	65.9	70.7	54.8	11.1	79.9	65.0	72.7	56.6	8.4
7	82.1	69.2	73.7	57.4	11.8	82.2	69.7	74.9	60.5	9.2
8	87.7	77.8	76.5	63.7	14.1	87.5	77.1	81.0	67.5	9.6
9	78.7	74.1	73.9	68.1	6.0	78.8	74.2	74.0	68.2	6.0
10	87.3	79.2	83.8	74.4	4.8	87.4	79.9	83 6	75.5	4.4
11	87.4	77.5	84.0	72.6	4.9	88.1	78.8	85.8	74.5	4.3
12	88.8	78.4	85.8	73.2	5.2	88.8	78.1	86.2	74.1	4.0
13	85.7	79.2	83.6	74.9	4.3	85.7	78.9	83.4	75.2	3.7
14	82.4	78.6	80.7	75.2	3.4	82.5	78.3	80.9	76.1	2.2
15	76.2	72.3	75.4	70.4	1.9	76.5	72.7	75.4	70.2	2.5
16	76.6	72.4	75.7	66.7	5.7	76.9	71.5	75.5	68.4	3.1
17	84.5	73.8	83.3	67.5	6.3	84.6	73.6	82.8	67.6	6.0
18	79.2	60.8	77.6	49.6	11.2	79.2	60.9	78.1	53.2	7.7
19	87.0	77.7	84.8	73.2	4.5	86.7	77.9	85.2	72.8	5.1
20	..	..	..	..	..	87.1	81.7	85.2	78.6	3.1
21	..	..	..	..	..	84.6	79.3	81.6	73.9	5.4
22	..	..	..	..	..	90.6	78.3	87.2	72.6	5.7
23	..	..	..	..	..	84.3	76.8	82.1	73.3	3.5
24	..	..	..	..	..	79.0	71.8	77.4	66.5	5.3

Table V. Effect of Erasure on Gloss

Sample	Erasure in machine direction					Erasure across machine direction				
	Before		After			Before		After		
	In	Across	In	Across	Ratio	In	Across	In	Across	Ratio
2	12.9	11.0	29.9	16.7	1.9	11.9	9.5	16.7	22.6	1.8
3	12.8	10.9	47.1	25.1	3.0	12.8	11.1	26.7	44.0	3.0
4	15.2	13.1	42.6	22.5	2.3	18.0	13.4	22.8	36.0	1.9
5	17.0	13.5	13.6	9.4	0.8	17.2	13.1	9.1	11.0	0.7
6	19.3	16.2	44.0	24.0	1.9	16.5	14.0	24.5	37.3	2.0
7	18.6	16.8	36.5	20.7	1.6	17.8	15.8	25.4	40.2	2.0
8	16.7	15.0	41.0	22.9	2.0	16.7	14.9	24.8	36.5	1.9
9	27.1	23.0	35.4	19.1	1.1	26.1	22.9	20.0	30.2	1.0
10	25.1	21.8	24.2	14.5	0.8	23.5	19.2	16.0	22.9	0.9
11	24.7	21.1	24.0	14.7	0.8	23.8	19.3	12.3	16.7	0.7
12	21.7	19.5	27.8	15.9	1.1	22.2	19.1	16.9	24.3	1.0
13	32.4	25.9	19.1	11.6	0.5	31.4	23.8	12.8	15.2	0.5
14	45.6	36.4	19.6	12.2	0.4	45.0	34.5	12.2	13.6	0.3
15	29.0	22.9	16.0	11.3	0.5	30.5	25.5	13.2	16.8	0.5
16	27.7	22.6	11.1	9.3	0.4	24.0	19.7	10.5	12.0	0.4
17	39.3	32.5	12.6	10.2	0.3	39.0	34.9	10.0	11.2	0.3
18	29.5	24.3	21.5	13.5	0.7	25.1	21.1	14.0	17.2	0.7
19	45.4	37.8	15.5	10.6	0.3	44.3	35.9	10.9	11.0	0.3
20	..	..	..	..	..	13.1	10.9	9.2	10.9	0.8
21	..	..	..	..	..	13.4	12.0	8.3	9.7	0.7
22	..	..	..	..	..	22.5	20.0	10.4	13.6	0.6
23	..	..	..	..	..	35.0	31.0	10.0	12.5	0.3
24	..	..	..	..	..	12.8	11.0	9.0	10.8	0.8

latter, it was found that, in general, the ink lines which were drawn parallel with the machine direction of the paper disappeared slightly faster than those drawn perpendicular to the machine direction.

Upon examination of the data presented in Table III, it is observed that the number of erasing strokes required to remove the ink lines varied from a minimum of 57 to a maximum of 1500 strokes. For 13 of the first 18 samples, an equal or larger number of strokes was made on these specimens for which the erasing stroke was parallel with the machine direction of the paper. The amount of material removed by erasure varied between 51.7 and 117 mg. for specimens $2^1/_2$ inches square. As a rule, the loss in weight was greater for those specimens abraded in the machine direction of the paper. The maximum difference in weight, caused by abrasion in the two directions, is observed for sample 16, where 117 mg. were removed in the machine direction stroke and 60.8 mg. were removed in the across-machine direction stroke. However, the range in weight loss is surprisingly small, which is suggestive of the possibility that the depth of penetration of the ink in the various samples does not cover a large range.

The reflectivity values R_∞ (reflectance of a specimen backed by a thick pad consisting of the same paper as that of the specimen) and R_0 (reflectance of specimen backed by a black body) obtained with the G.E. recording spectrophotometer at a wavelength of 555 mmu are presented in Table IV. The reflectance values obtained on the original specimens before erasure are presented in columns 2, 3, 7, and 8; those obtained on the specimens after erasure are presented in columns 4, 5, 9, and 10. The sixth and last columns present the differences in the reflectance R_0 of the specimens before and after erasure.

In addition to the expected decrease in the opacity of the samples, it will be noted that erasure also had an adverse effect on the reflectivity R_∞. The observed decreases in R_∞ varied from a minimum of 0.8% for sample 15, to a maximum of 12.1% for sample 3. Such changes in the reflectivity of the paper are large when it is considered that the eye is capable of distinguishing differences of the order of 0.5 to 2%. In order to check whether the ink or the abrasion wheels were responsible for the observed drop in the reflectivity R_∞, complete color curves were obtained for sample 8. These curves revealed that possibly both the ink and the abrasion wheel contributed to the observed change.

In a further search for an explanation of the observed changes in the reflectivity of these samples, the specific scattering and absorption coefficients (optical) were calculated for samples 2 through 12. These calculations indicated that the specific scattering coefficient was reduced slightly, and the specific absorption coefficient was increased, by abrasion. The maximum change in the specific absorption coefficient was calculated for samples 3 and 8. By way of comparison, it is interesting to note that these two samples also showed the greatest changes in reflectivity. The increase in specific absorption coefficient is indicative of colorimetric contamination by the eraser, or ink, or both. The effects of abrasion on the luminous reflectance of single sheets of the papers used in this study are approximated by the reflectance values R_0 and by the differences $R_0 - R'_0$. The reflectance values R_0 closely resemble the sort of thing a person would observe when looking at a single sheet of paper, without any backing.

The results of the gloss measurements obtained with the special glossmeter are presented in Table V, where the data obtained on the original specimens, before erasure, are presented in columns 2, 3, 7, and 8 and the data obtained on the specimens after erasure are presented in columns 4, 5, 9, and 10. The sixth and last columns present the ratios which were calculated by dividing the average of the "in" and the "across" readings, obtained on the abraded specimens, by the average of the "in" and "across" readings obtained on the unabraded specimens. A ratio greater than one indicates that the gloss on the abraded specimens is higher than that of the original sample, whereas a ratio less than one indicates a decrease in gloss. In examining these ratios, it will be seen that erasure has a pronounced effect on the gloss of the various papers.

A significant increase in gloss is noted in six of the samples and in the remaining samples the gloss was decreased considerably. Inspection of the values found in columns 4, 5, 9, and 10 shows that the gloss is greater in the direction of the erasing stroke. This might be attributed to a tendency of the eraser to orient surface fibers in the direction of the stroke.

For the purpose of showing specimens having different and representative erasing characteristics, five photographs, obtained at a magnification of three, are presented in Fig. 3. The upper half of each photograph presents a view of the original sample containing a vertical ink line as it would appear prior to abrasion, and the lower half of the photograph shows a view of the abraded surface and the ink line applied after

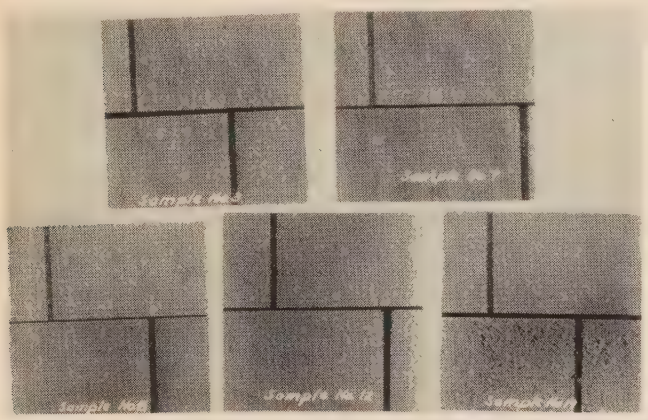

Fig. 3

abrasion. A slight trace of the original line on the lower half of the photograph (i.e., a trace of the line removed by abrasion) may be seen directly below the line appearing on the unabraded surface.

Upon examining the photographs for samples 3, 7, and 8, it is observed that abrasion removed most of the cockle originally present in the samples; visual inspection of the specimens and measurement showed that the gloss was increased appreciably. Sample 3 exemplifies a paper showing the greatest increase in gloss. The point of interest in the photographs for samples 7 and 8 concerns the writing quality of these two papers before and after abrasion. The appearance of the ink lines on the unabraded papers is very nearly the same, yet the lines on the abraded surfaces of the two samples are quite different. The line on the abraded surface of sample 8 is superior in appearance to the line drawn on the original unabraded surface; the line on the abraded surface of sample 7 is quite inferior because of feathering.

The photograph for sample 12 presents a typical example of a paper on which abrasion had a very small effect on the gloss; the gloss readings obtained before and after abrasion were essentially the same.

Sample 19 exemplifies the characteristics of a paper on which abrasion produced a considerable amount of surface fuzz. The writing quality of the abraded surface is poor. This was generally found to be the case for all the abraded specimens on which a considerable amount of fuzz was developed by erasure.

REMARKS ON THE ABRADING WHEELS

In the work done thus far, uniformity of the abrading wheels has been of relatively small importance. However, uniformity and reproducibility are two characteristics of an abrading material which must be considered in the standardization of a test method involving erasability of paper. Of interest and importance in this respect are the results obtained with several Calibrase wheels, all type CS17F, which were received on different orders. It was found that the wheels received on the first orders wore down considerably faster than those obtained in a subsequent shipment. The first wheels received wore down after approximately 15,000 erasing strokes (total), whereas the wheels received at a later date could be utilized for approximately 160,000 strokes, under roughly comparable conditions. In addition to this observation, it was also noticed that a wheel which wore down slowly did not always produce uniform abrasion. This wheel apparently had a tendency to clog and thus removed more material from the sample on the first inch of the erasing stroke than it did on the remaining 2 inches of the stroke. The abraded surfaces obtained with the first wheels were all quite uniform. The rapid wearing away of these wheels apparently preventing their clogging.

LITERATURE CITED

1. Schur, Milton O., and Levy, Robert M., *Paper Trade J.* 122, no. 12: 47–51 (March 21, 1946); *Tech. Assoc. Papers* 29: 160–163 (1946).

Received April 29, 1950. This report is one of a series issued as a part of the Instrumentation Program of the American Paper and Pulp Association. The data in this paper were reported to the Association as Report No. 43, Part II, on Feb. 15, 1948. The first artiele in this series appeared in *Tappi* 34, no. 2: 89A (1950).

LETTERS TO THE EDITOR

Routine Control Method RC-143 (Correction)

To the Editor of *Tappi:*

I would like to draw your attention to what appears to be an error in TAPPI Routine Control Method RC-143 (Palmrose Method).

The directions call for the preparation of $N/8$ potassium Codate solution by dissolving 3.569 grams of the salt in one liter of distilled water. This, however, would result in a $N/10$ solution. The correct weight, I believe, should be 4.459 grams, in order to give a $N/8$ solution.

I might add that I consider the above Palmrose method, as well as the Birchard method, superior to the Winkler method, as described in TAPPI Standard T 604 m-45, for the analysis of bisulphite cooking liquor.

James W. Purdey, *Sulphite Mill Control Engineer*
Abitibi Power & Paper Co. Ltd.
Thunder Bay Division, Port Arthur, Ont.

Note: Mr. Purdey's letter was submitted to Roger C. Griffin, Chairman of the TAPPI Standards Committee, who writes: "I have a copy of Mr. Purdey's letter regarding Routine Control Method RC-143.

"The molecular weight of potassium iodate is 214.03. A $N/10$ solution would be $^1/_{60}$ of this, or 3.567 grams per liter. A $N/8$ solution would be $^5/_4$ of the latter, or 4.459 grams. He is correct: RC-143 is wrong."

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Calendar of TAPPI Meetings

NATIONAL

Second Coating Conference, Statler Hotel, Boston, Mass., April 18–20, 1951
- General Chairman—J. H. Heuer, A.P.W. Products, Inc., Albany, N. Y.
- Program Chairman—Alfred D. Bonanno, Champion-International Co., Lawrence, Mass.

First Corrugated Container Conference, Statler Hotel, Cleveland, Ohio. May 18–19, 1951
- General Chairman, F. D. Long, Container Corp. of America, Chicago, Ill.

LOCAL SECTIONS

OHIO SECTION:
April 10, 1951, Manchester Hotel, Middletown, Ohio.

PACIFIC SECTION:
April 13, 1951, Longview, Wash.

LAKE ERIE PAPERMAKERS AND CONVERTERS:
April 20, 1951, Hickory Grill, Cleveland, Ohio.

DELAWARE VALLEY SECTION:
April 26, 1951, Engineers Club, Philadelphia, Pa.

CHICAGO SECTION:
April 16, 1951, Chicago Bar Assoc., Chicago, Ill.

EMPIRE STATE SECTION: Spring Meeting
June 27–30, 1951, Whiteface Inn, Lake Placid, N. Y.

NORTHERN GROUP, EMPIRE STATE SECTION:
April 12, 1951, Woodruff Hotel, Watertown, N. Y.

KALAMAZOO VALLY SECTION:
April, 5, 1951, Hotel Harris, Kalamazoo, Mich.

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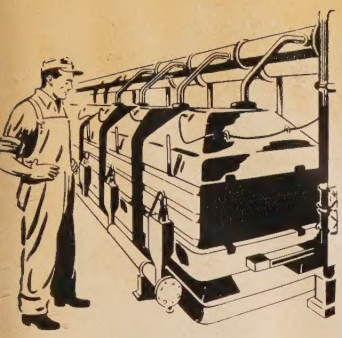

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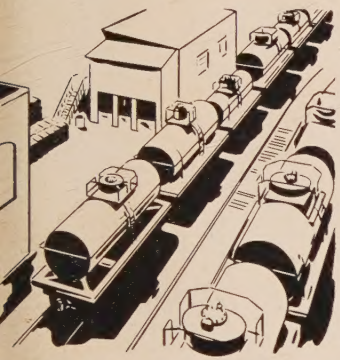

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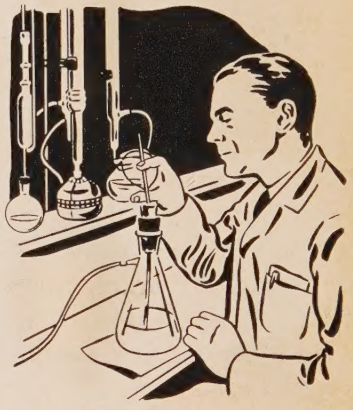

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